

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

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TECHNICAL MANUAL

DIRECT SUPPORT, GENERAL SUPPORT, AND

DEPOT MAINTENANCE MANUAL

CRANE, WHEEL MOUNTED ;

5 TON AT 10-FOOT RADIUS,

DIESEL ENGINE DRIVEN, 4X4,

ROUGH TERRAIN, AIR TRANSPORTABLE

(HANSON MACHINERY COMPANY, MODEL H446A)

FSN 3810-859-2404

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HEADQUARTERS, DEPARTMENT OF THE ARMY

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HEADQUARTERS  
 DEPARTMENT OF THE ARMY  
 WASHINGTON, D.C., 20 July 1973

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# CHAPTER 1

## INTRODUCTION

### Section I. GENERAL

#### 1-1. Scope

This manual is for your use in maintaining the Hanson Model H466A, wheel mounted, 5-ton, DED, rough terrain crane.

#### 1-2. Maintenance Forms and Records

Maintenance forms and records that you are required to use are explained in TM 38-750.

#### 1-3. Reporting of Errors

You can improve this manual by calling attention to errors and by recommending improvements, using DA Form 2028 (Recommended Changes to Publications) or by a letter, and mail direct to

Commander, U. S. Army Troop Support Command, ATTN: AMSTS-MPP, 4300 Goodfellow Boulevard, St. Louis, Mo. 63120. A reply will be furnished directly to you.

#### 1-4. Destruction of Army Material to Prevent Enemy Use

Procedures for the destruction of Army material to prevent enemy use are explained in TM 750-244-3.

#### 1-5. Administrative Storage

Administrative storage procedures are explained in TM 740-90-1.

### Section II. DESCRIPTION AND DATA

#### 1-6. Description

The Hanson Model H446A Crane is a 5 ton, diesel engine driven, wheeled carrier mounted unit, and is equipped with a telescoping boom that may be equipped with a manually installed boom extension unit. The crane is designed to ford streams to a maximum depth of 36 inches without affecting its operational capabilities. The maintenance paragraphs of this manual contain detailed descriptions of its components.

##### NOTE

An anchoring device located on the boom is to be used as a means of anchoring the boom assembly when removing and handling the crane superstructure.

#### 1-7. Tabulated Data

*a. Identification and Instruction Plates.* The crane has 17 major identification, instruction and caution plates. Refer to TM 5-3810-290-12 for information related to these plates.

##### *b. Tabulated Data.*

##### (1) Engine.

|              |                                 |
|--------------|---------------------------------|
| Manufacturer | Detroit Diesel Engine Div., GMC |
| Type         | Diesel, Series 6V-53            |
| Model        | 5057-5240                       |
| Bore         | 3.875 inches                    |
| Stroke       | 4.5 inches                      |

|  |   |
|--|---|
| Injector type                            | S50   |
| Fuel                                     | DE-2, Regular Grade<br>DE-1, Winter Grade<br>DE-A, ArDE-A, Arctic Grade |
| Total displacement                       | 318 cubic inches  |
| Compression ratio                        | 17:1  |
| No. of cylinders                         | 6   |
| Governed speed                           | 2800 rpm MAXIMUM  |
| Rotation (at flywheel end)               | CCW   |
| Cooling                                  | Liquid  |
| (2) <i>Air compressor.</i>               |   |
| Manufacturer                             | Bendix-Westinghouse   |
| Model                                    | TU-FLO 500  |
| Pressure                                 | 105 psi (max.)  |
| Capacity                                 | 12 cfm  |
| (3) <i>Pump, hydraulic steering.</i>     |   |
| Manufacturer                             | Vickers, Inc.   |
| Model                                    | V20F  |
| Capacity                                 | 8 GPM   |
| Pressure                                 | 1750 PSI  |
| (4) <i>Pump, crane hydraulic system.</i> |   |
| Manufacturer                             | Vickers, Inc.   |
| Model                                    | 3525V25A17  |
| Shaft end pump:                          |   |
| Capacity                                 | 25 GPM  |
| Pressure                                 | 2000 PSI  |
| Cover end:                               |   |
| Capacity                                 | 17 GPM  |
| Pressure                                 | 2000 PSI  |

|                   |                                       |
|-------------------|---------------------------------------|
| Axle differential | 11½ quart (each)                      |
| Fuel tanks        | 50 gallons (each)                     |
| Engine crankcase  | 18 quarts (22 qt. with filter change) |
| Coolant system    | 7 gallons                             |
| Crane tank        | 50 gallons                            |
| Transmission      | 8¼ gallons                            |
| Transfer case     | 4 quarts                              |
| Planetary housing | 2 quarts (each)                       |

Gear reduction case, hoist  
 Gear reduction case, swing  
 Cable, hoist, steel, 6 x 19 preformed  
 Pump gear box  
*c. Nut, Bolt, a*  
 provides data on

*Table 1-1. Special nut, bolt, and stud torque*

| Application                              |
|--|
| End plate bolt                           |
| Air box cover                            |
| Main bearing bolt (assembly)             |
| Exhaust manifold outlet flange nut       |
| Oil pan bolts                            |
| Lifter bracket bolts                     |
| Blower drive coupling to gear hub bolt   |
| Camshaft intermediate bearing lock screw |
| Accessory drive to gear bolt             |
| Camshaft nut                             |
| Blower drive gear hub nut                |
| Idler gear hub and spacer bolts          |
| Idler gear hub and spacer bolts          |
| Tachometer drive cover bolts             |
| Fuel pipe nut                            |
| Rocker arm bracket bolt                  |
| Exhaust manifold nuts                    |
| Injector clamp stud                      |
| Exhaust manifold stud                    |
| Crankshaft front cover                   |
| Crankshaft front cover                   |
| Connecting rod nut-castellated           |
| Crankshaft end bolt                      |
| Flywheel bolts                           |
| Flywheel hsg bolts                       |
| Flywheel hsg bolts                       |
| Camshaft end bearing bolt                |

NOTE. Torque values are listed in the assembly, repair, and installation instructions for the re

*d. Wiring. Refer to TM 5-3810-290-12 for*

# **CHAPTER 2**

## **DIRECT SUPPORT AND GENERAL S**

### **MAINTENANCE INSTRUCTION**

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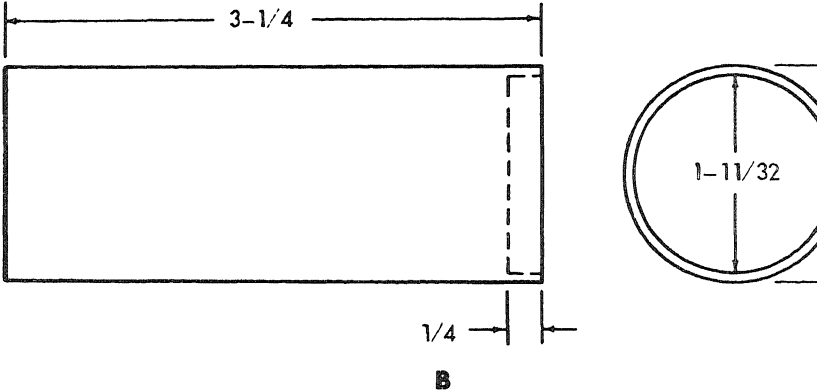
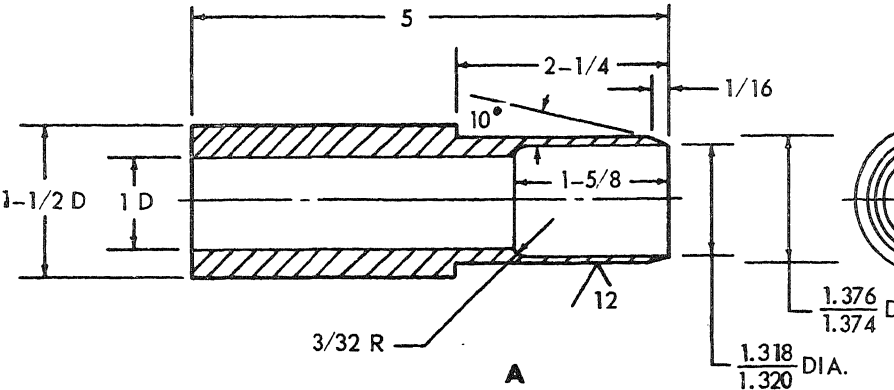
#### **Section I. REPAIR PARTS, SPECIAL TOOLS, AND**

##### **2-1. Special Tools and Equipment**

Special tools and equipment required to perform direct and general support and depot maintenance

on the crane are sl  
are listed in table  
and are listed in

NOTE: ALL DIMENSIONS ARE IN INCHES.



SAME THREAD AS WHEEL NUT,  
APPROXIMATELY  $3 \frac{5}{16}$ -12 IN.

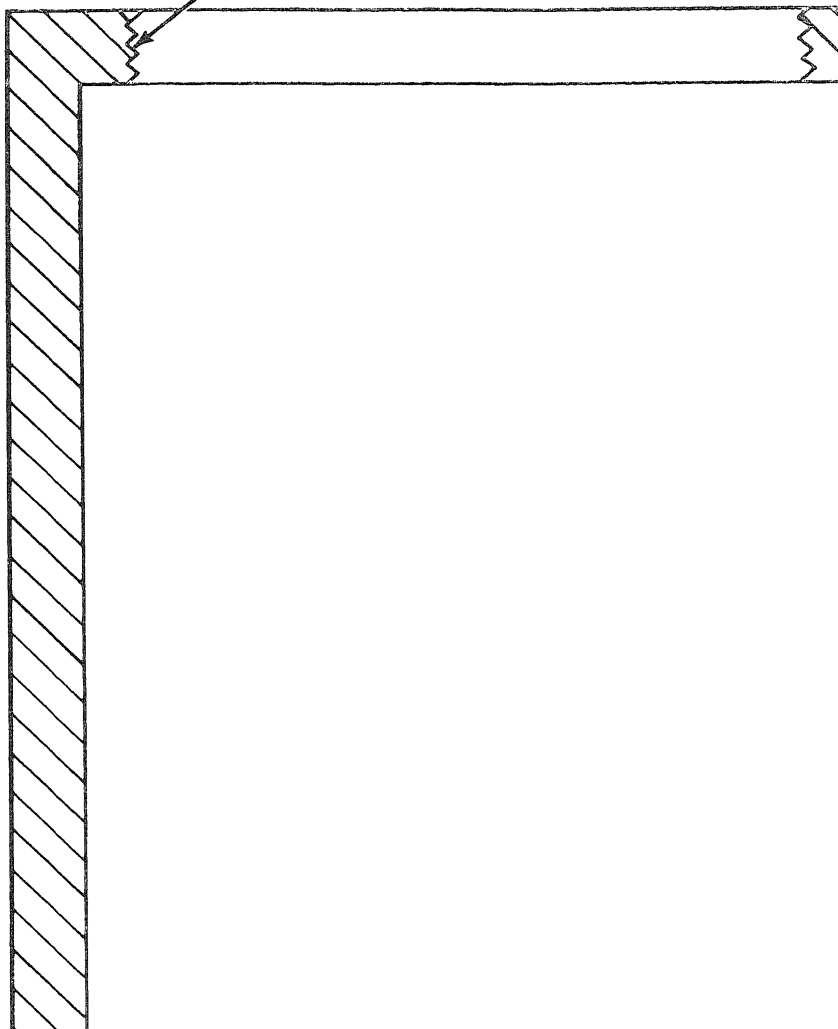




Table 2-1. Special Tools and Equipment

| Item        | Reference |           |            |
|-------------|-----------|-----------|------------|
|             | Figure    | Paragraph |            |
| Seal pilot  | 2-1A      | 4-11      | Install re |
| Seal driver | 2-1B      | 3-16      | Install se |
| Seal driver | 2-1C      | 3-8       | Install se |
| Seal driver | 2-1C      | 3-11      | Install se |
| Wheel seal  |           |           |            |
| Pilot       | 2-2       | 4-17      | Hydrauli   |

## 2-2. Maintenance Repair Parts

Repair parts and equipment are listed and illustrated in TM 5-3810-290-34P: the repair parts

and special too  
general support

## Section II. TROUBLESHOOTING

### 2-3. General

This section contains troubleshooting information for locating and correcting most of the troubles which may develop in the crane.

determine prob  
take. You sho  
and corrective

### 2-4. Troubleshooting Chart

a. In table 2-2, each malfunction for an individual component, unit, or system is followed by a list of tests or inspections which will help you to

b. This man  
may occur. n  
corrective actio  
not corrected b  
your supervisor

Table 2-2. Troubleshooting

| MALFUNCTION | TEST OR INSPECTION | CORRECTIVE ACTION |
|-------------|--------------------|-------------------|
|-------------|--------------------|-------------------|

*Table 2-2. Troubleshooting—Continued*

| MALFUNCTION                                   | TEST OR INSPECTION                               | CORRECTIVE ACTION  |
|---|--|--|
| <b>3. BOOM HOIST OPERATES SLUGGISHLY</b>      |  |  |
| Step 1.                                       | Check for low hydraulic pressure.                | Clean tank, filters, and lines (para 6-8). Repair or replace defective   |
| Step 2.                                       | Check for defective boom hoist cylinder.         | Repair or replace a defective boom hoist cylinder (para 3-5).  |
| Step 3.                                       | Check for defective rotary seal unit.            | Repair or replace defective rotary seal unit (para 3-13).  |
| Step 4.                                       | Check for defective multi-unit control valve.    | Repair or replace defective multi-unit control valve (para 3-19).  |
| <b>4. BOOM EXTENSION OPERATES SLUGGISHLY</b>  |  |  |
| Step 1.                                       | Check for low hydraulic pressure.                | Clean tank, filters, and lines (para 6-8). Repair or replace defective   |
| Step 2.                                       | Defective boom extension cylinder.               | Repair or replace defective boom extension cylinder (para 3-4).  |
| Step 3.                                       | Inspect for excessively worn wear shoes.         | Replace worn wear shoes (para 3-6).  |
| Step 4.                                       | Check for defective multi-unit control valve.    | Repair or replace defective multi-unit control valve (para 3-19).  |
| Step 5.                                       | Check adjustment of eccentric roller.            | Adjust eccentric roller as required (TM 5-3810-290-12)   |
| <b>5. MULTI-SECTION VALVES MALFUNCTIONING</b> |  |  |
| Step 1.                                       | Check for sticky or sluggish valve spool action. | Replace a defective valve assembly (TM 5-3810-290-12) Loosen v shim body to relieve strain (TM 5-3810-290-12). |
| Step 2.                                       | Check control linkage for binding.               | Eliminate any control linkage binding (TM 5-3810-290-12)   |

## STEERING

### HYDRAULIC STEERING SYSTEM SLUGGISH OR INOPERATIVE.

- Step 1. Check for low hydraulic pressure.  
Clean filter and lines (para 6-8). Repair or replace defective eng (para 4-17).
- Step 2. Check for defective power steer control valve.  
Repair or replace defective power steer control valve (para 5-30).

*Table 2-2. Troubleshooting—Continued*

| MALFUNCTION | TEST OR INSPECTION | CORRECTIVE ACTION |
|-------------|--------------------|-------------------|
|-------------|--------------------|-------------------|

## TRANSMISSION

### 1. TRANSMISSION OVERHEATS

- Check for low clutch pressure (slipping clutches).  
See paragraph 2 below.

### 2. TRANSMISSION HAS LOW CLUTCH PRESSURE

- Step 1. Check for control valve stuck in open position or defective.  
Clean, repair, and / or replace defective control valve (para 5-3).
- Step 2. Inspect solenoid valve for leaking seals.  
Repair or replace defective solenoid valve (para 5-3).

### 3. TRANSMISSION OIL PRESSURE LOW

- Step 1. Check for low clutch pressure (slipping clutches).  
See paragraph 2 above.
- Step 2. Check pump suction tube for clogged screen.  
Clean or replace clogged screen (para 5-4).

### 4. TRANSMISSION PERFORMS POORLY

- Check for too low engine speed.

## NOTE

The torque converter absorbs and transmits power in proportion to engine speed. The converter is carefully matched at the rated speed. When the machine is brought to stall, the engine speed should be 2450 rpm. A full converter stall usually indicates that engine and converter are not properly matched under ENGINE.

### 5. TRANSMISSION HAS LOW LUBRICATION OIL PRESSURE

- Inspect for defective control valve.  
Clean, repair, or replace defective control valve (para 5-5).

### 6. TRANSMISSION HAS NO OIL PRESSURE

- Step 1. Check pump suction tube for clogged screen.  
Clean or replace clogged screen (para 5-4).
- Step 2. Check for defective oil pump.

Table 2-2. Troubleshooting—Continued

| MALFUNCTION                     | TEST OR INSPECTION | CORRECTIVE ACTION  |
|---------------------------------|--------------------|--|
|                                 | Step 3.            | Check for defective fuel pump.<br>Repair or replace defective fuel pump (para 4-23).   |
|                                 | Step 4.            | Check injector control racks for being out of full fuel position.<br>Adjust injector fuel control racks to correct position (para 4-67). |
|                                 | Step 5.            | Check for improperly adjusted governor.<br>Adjust governor (para 4-32).  |
| <b>2. ENGINE HARD TO START</b>  |                    |  |
|                                 | Step 1.            | Check for burnt or sticking exhaust valves.<br>Clean and / or replace defective exhaust valves (para 4-38).                              |
|                                 | Step 2.            | Check for broken compression rings.<br>Replace broken compression rings (para 4-56).   |
|                                 | Step 3.            | Inspect for leaking cylinder head gasket.<br>Replace defective cylinder head gasket (para 4-35).   |
|                                 | Step 4.            | Check for incorrect exhaust valve clearance adjustment.<br>If necessary, adjust exhaust valves (para 4-65).                              |
|                                 | Step 5.            | Inspect for dirty or defective injectors.<br>Clean and / or repair defective injectors (para 4-40).                                      |
|                                 | Step 6.            | Inspect blower for improper functioning.<br>Replace or repair defective blower (para 4-30).  |
|                                 | Step 7.            | Check non-functioning air inlet valve.<br>Replace or repair defective air inlet assembly (para 4-28).                                    |
| <b>3. ENGINE STOPS SUDDENLY</b> |                    |  |
|                                 | Step 1.            | Check for inoperative fuel pump.<br>Repair or replace defective fuel pump (para 4-23).   |
|                                 | Step 2.            | Check for blocked air intake.<br>Repair defective air inlet system (para 4-26, 4-27, 4-28).  |
|                                 | Step 3.            | Check for mechanical failure.<br>See paragraph 4 below.  |
|                                 | Step 4.            | Check for low oil pressure.<br>Repair or replace defective oil pump (para 4-54).   |
|                                 | Step 5.            | Check for low fuel pressure.<br>Repair or replace defective fuel pump (para 4-23).   |
|                                 | Step 6.            | Check for high engine temperature.<br>Repair a defective radiator (para 4-4).  |
|                                 | Step 7.            | Check for defective variable speed governor.<br>Repair or replace a defective variable speed governor (para 4-32).                       |

Table 2-2. Troubleshooting—Continued

| MALFUNCTION                                 | TEST OR INSPECTION  | CORRECTIVE ACTION   |
|---|---|---|
| Step 11.                                    | Check crankshaft for excessive end clearance.                           | If crankshaft has excessive end clearance, replace thrust washers.    |
| Step 12.                                    | Check for loose flywheel.   | Tighten loose flywheel mounting capscrews (para 4-43).                |
| <b>5. ENGINE MISSES OR RUNS ERRATICALLY</b> |   |   |
| Step 1.                                     | Check for improperly adjusted injector control tube.                    | If necessary, adjust injector control tube (para 4-67).               |
| Step 2.                                     | Check for out-of-time fuel injectors.                                   | Time the fuel injectors (para 4-66).                                  |
| Step 3.                                     | Check for faulty fuel injectors.  | Repair or replace faulty fuel injectors (para 4-40).                  |
| Step 4.                                     | Check for low cylinder compression due to damaged liners, broken rings. | Replace defective pistons, rings, (para 4-58) and liners (para 4-58). |
| Step 5.                                     | Check for burned or sticking exhaust valves.                            | Replace defective exhaust valves and seats (para 4-38).               |
| <b>ENGINE LACKS POWER</b>                   |   |   |
| Step 1.                                     | Check for improperly adjusted injector control tube.                    | If necessary, adjust injector control tube.                           |
| Step 2.                                     | Check for out-of-time fuel injectors.                                   | If necessary, correctly time fuel injectors (para 4-66).              |
| Step 3.                                     | Check for faulty fuel injectors.  | Repair or replace faulty fuel injectors (para 4-40).                  |
| Step 4.                                     | Check for low cylinder compression due to damaged liners, broken rings. | Replace defective pistons, rings and liners (para 4-56).              |
| Step 5.                                     | Check for burned or sticking exhaust valves.                            | Replace defective exhaust valves and seats (para 4-38).               |
| Step 6.                                     | Check for faulty fuel pump.   | Repair or replace a faulty fuel pump (para 4-23).                     |
| Step 7.                                     | Check for clogged cylinder liner air inlet parts.                       | If necessary, clean clogged inlet parts (para 4-58).                  |
| <b>7. ENGINE EXHAUST SMOKY</b>              |   |   |
| Step 1.                                     | Check for improper fuel injector timing.                                | If necessary, correctly time fuel injectors (para 4-66).              |

Table 2-2. Troubleshooting—Continued

| MALFUNCTION                                 | TEST OR INSPECTION   | CORRECTIVE ACTION |
|---|--|-------------------|
| <b>9. ENGINE HAS LOW OR NO OIL PRESSURE</b> |  |                   |
| Step 1.                                     | Check for worn connecting rod bearings, crankshaft, or main bearings.<br>Replace defective connecting rod bearings (para 4-57) crankshaft and 4-60). |                   |
| Step 2.                                     | Check oil pump for sticking regulator valve.<br>If necessary, clean, repair, or replace the regulator valve (para 4-5).                              |                   |
| Step 3.                                     | Check oil pump for clogged screen.<br>If necessary, clean oil pump screen (para 4-42).   |                   |
| Step 4.                                     | Check for defective oil pump.<br>Repair or replace a defective oil pump (para 4-54).   |                   |
| Step 5.                                     | Check for lubricating oil diluted with fuel oil.<br>If necessary, replace injector preformed packing (para 4-40).                                    |                   |
| <b>10. ENGINE OIL CONSUMPTION HIGH</b>      |  |                   |
| Step 1.                                     | Check for defective oil pan gasket.<br>Replace defective gasket (para 4-41).   |                   |
| Step 2.                                     | Check for defective crankshaft oil seal.<br>Replace defective crankshaft oil seal (paras 4-44 and 4-53).   |                   |
| Step 3.                                     | Check for defective blower oil seal.<br>Replace defective oil seal (para 4-30).  |                   |
| Step 4.                                     | Check for leaking cylinder block end plate gaskets.<br>Replace defective gaskets (para 4-61).  |                   |
| Step 5.                                     | Check for worn, broken, or improperly installed oil control rings.<br>Replace defective oil control rings (para 4-56).                               |                   |
| Step 6.                                     | Check for worn pistons and cylinder liners.<br>Replace worn pistons (para 4-56) and liners (para 4-58).  |                   |

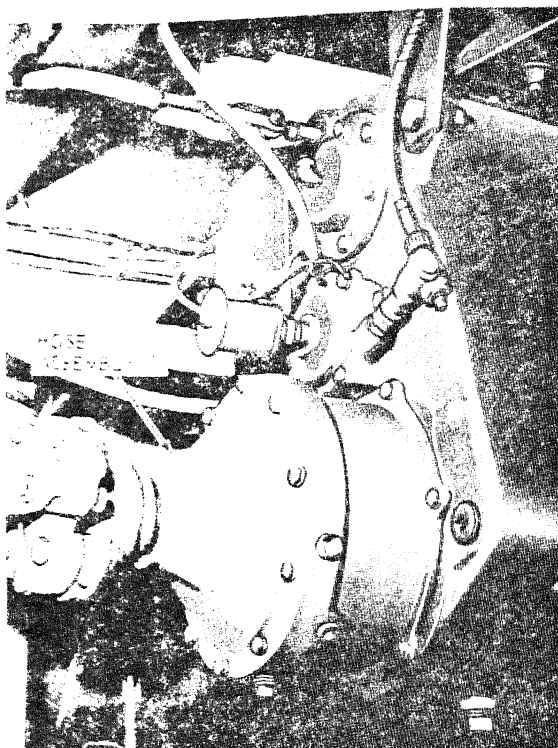
### Section III. REMOVAL AND INSTALLATION MAJOR COMPONENTS AND ASSEMBLIES

#### 2-5. Transfer Case

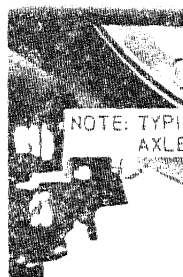
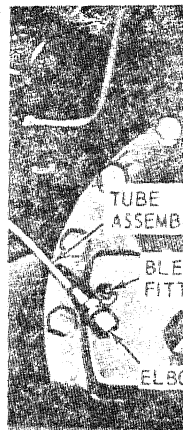
##### a. Removal.

(1) Remove the cab and crane superstructure (refer to TM 5-3810-290-12).

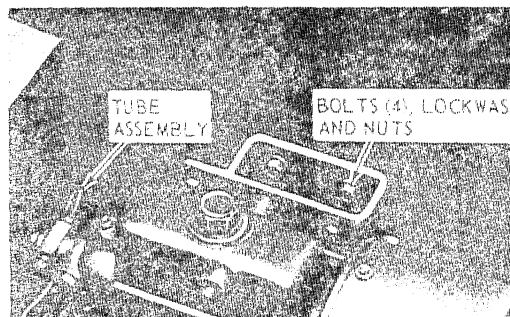
(6) Disconnect the transfer case.  
(7) Attach three capscrews



A. TRANSFER CASE HOSE CONNECTION



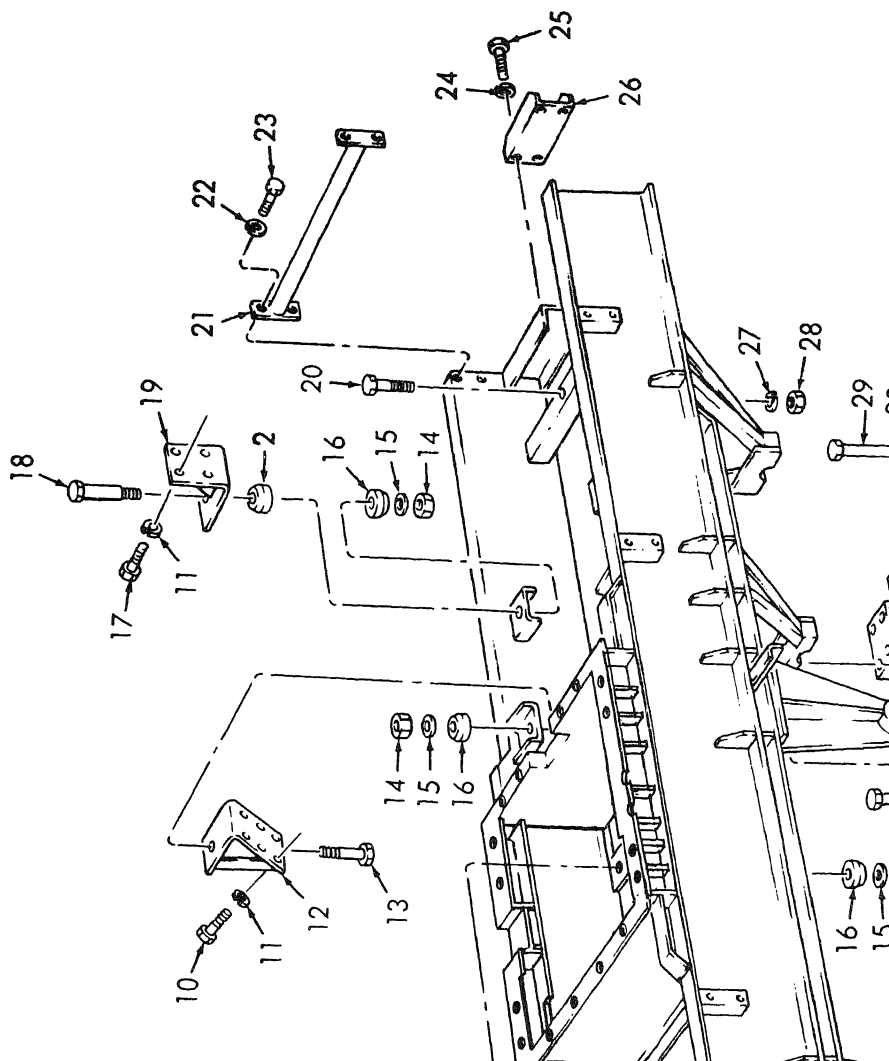
B. AXLE ASSEMBLY

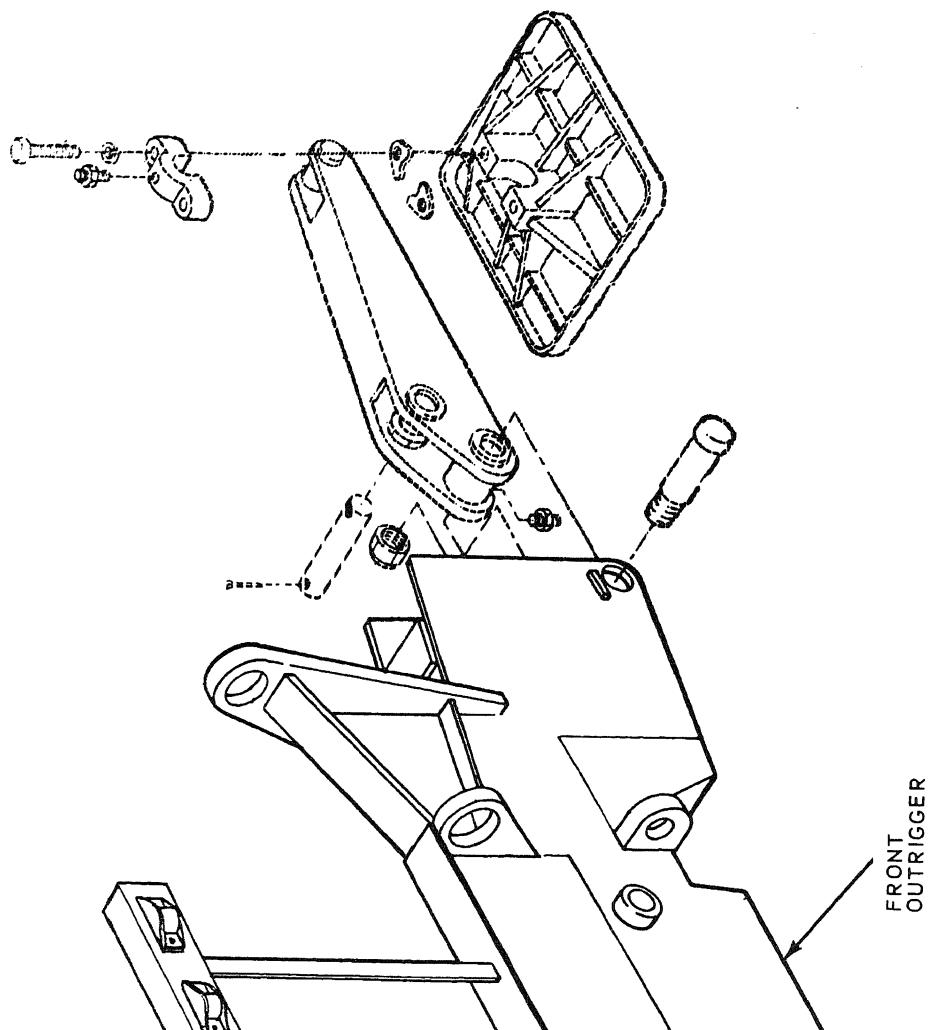


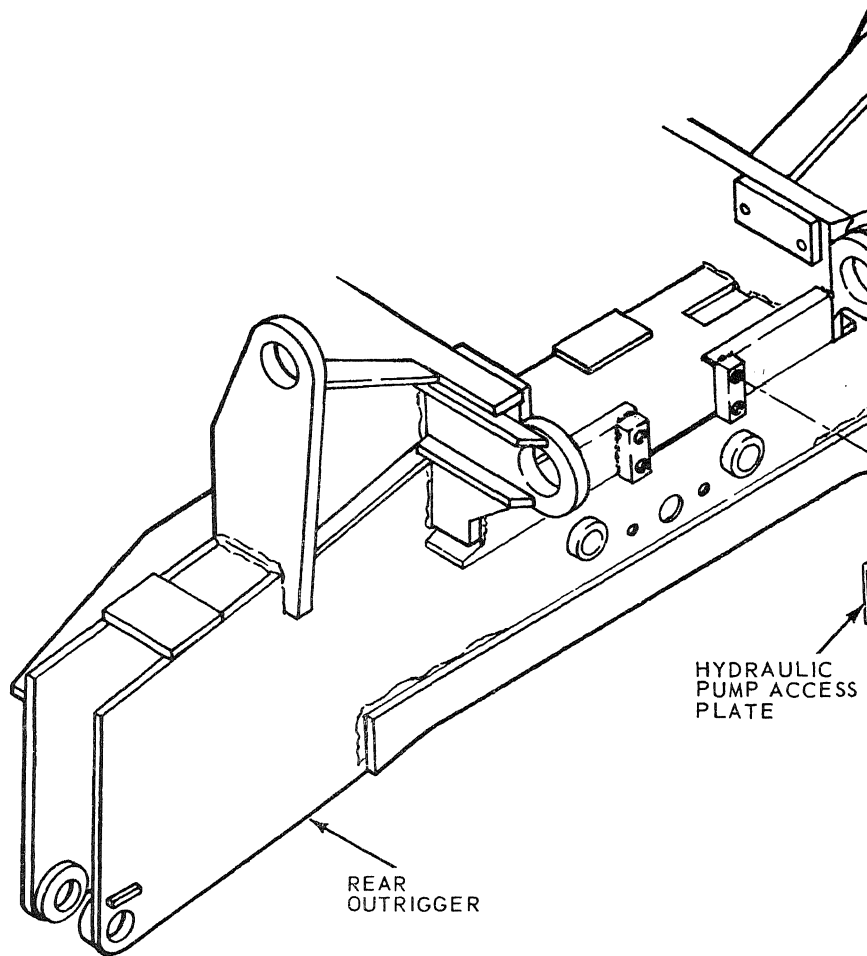
KEY to figure 2-4. (Sheet 1 of 3)

1. Frame, main
2. Insulator (5)
3. Bracket
4. Capscrew
5. Lockwasher
6. Capscrew (3)
7. Washer (3)
8. Sleeve (3)
9. Bracket
10. Capscrew (12)
11. Lockwasher (20)
12. Bracket (2)
13. Capscrew (2)
14. Nut (2)
15. Washer (7)
16. Insulator (6)
17. Capscrew (8)
18. Bolt, shoulder (2)
19. Bracket (2)
20. Capscrew (2)
21. Brace
22. Lockwasher (4)
23. Capscrew (4)
24. Lockwasher (4)
25. Capscrew (4)
26. Cover
27. Lockwasher (2)









(7) Disconnect air inlet piping (para 4-27) from air cleaner.

(8) Disconnect tube assembly for restriction indicator from air cleaner.

(9) Disconnect exhaust piping from exhaust manifolds on both sides of engine.

(10) Attach a suitable hoist to assembled rear hood panel, mufflers, and air cleaner.

(11) Remove four screws (15, fig. 6-5), nuts (6), and lock washers (7) that secure support (4) to fender supports.

(12) With hoist lift entire assembly clear of carrier.

(13) Drain the transmission (refer to TM 5-3810-290-12).

(14) Disconnect flexible drive cable for speed sensing switch.

(15) Disconnect the drive shaft between the transmission and transfer case (refer to TM 5-3810-290-12).

(16) Disconnect control cable from transmission range selector valve (refer to TM 5-3810-290-12).

(17) Disconnect electrical lead to transmission solenoid valve.

(18) Disconnect and remove transmission piping as required (refer to fig. 2-5).

(19) Attach transmission.

(20) Provide hardware by reusing old hardware and the cover for bell housing.

(21) Remove securing the drive the engine crank accessible.

(22) Remove washers (15), mountings.

(23) Remove washers that secure flywheel housing.

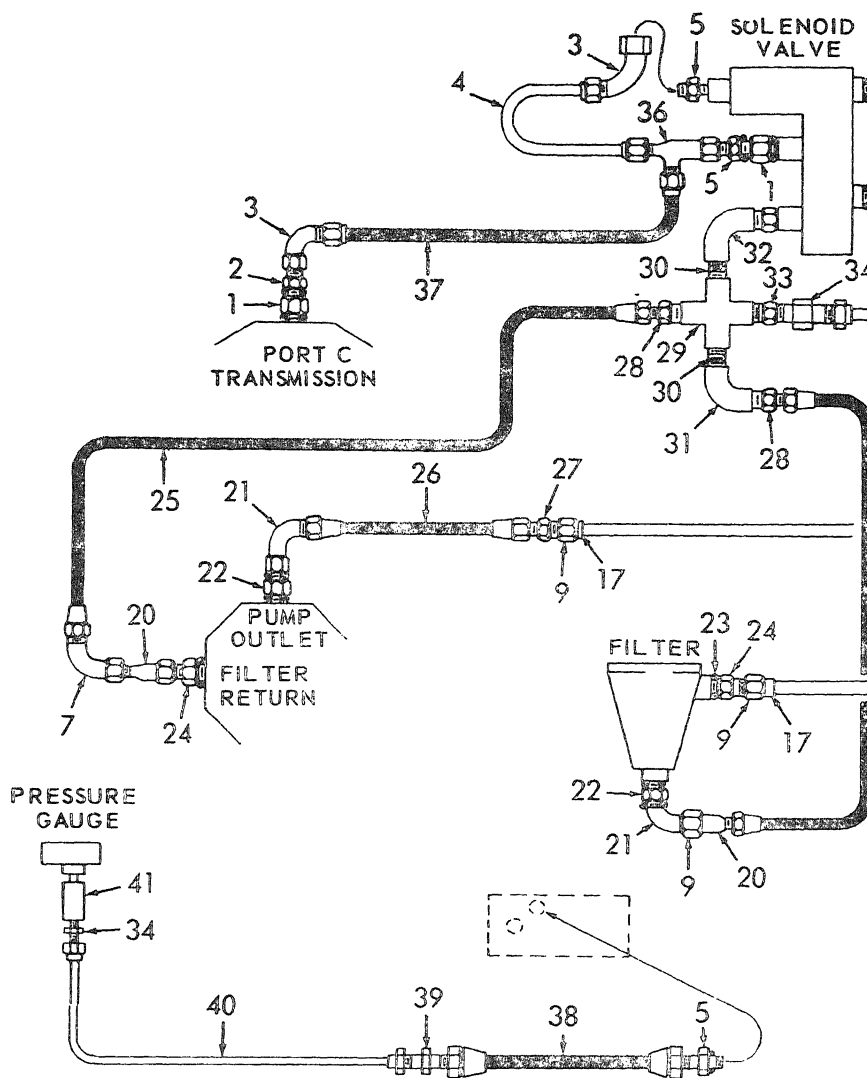
(24) Carefully remove assembly strain, damage to the

#### c. Installation

(1) Install in reverse order of

Install new in 4) when ins

(2) Service with current lu



## 2-8. Engine Assembly

a. *General.* The removal of the engine assembly from the carrier requires that the transmission be removed along with the engine. However the transmission may be removed without removal of the engine assembly (para 2-7).

### b. Removal.

(1) Remove the crane superstructure (refer to TM 5-3810-290-12).

(2) Remove the engine hood (refer to TM 5-3810-290-12).

(3) Remove the radiator (refer to TM 5-3810-290-12).

(4) Disconnect the drive coupling to the crane hydraulic pump (refer to TM 5-3810-290-12).

(5) Disconnect throttle and accelerator linkage from governor (refer to TM 5-3810-290-12).

(6) Disconnect wire leads for engine stop, emergency stop, and starting aid solenoids.

(7) Disconnect starting aid hose from air inlet housing.

(8) Disconnect hydraulic hoses from power steering pump.

(9) Disconnect cable assemblies from reverse polarity relay (refer to TM 5-3810-290-12).

(10) Disconnect fuel lines to and from fuel strainer mounted on rear fire wall (refer to TM 5-3810-290-12).

(11) Disconnect air inlet piping (para 4-27) from air cleaner.

(12) Disconnect tube assembly for restriction indicator from air cleaner.

(13) Disconnect exhaust piping from exhaust manifolds on both sides of engine.

(14) Attach a suitable hoist to assembled rear od panel, mufflers, and air cleaner.

(15) Remove four screws (15, fig. 6-5), nuts (6), and lockwashers (7) that secure support (4) to fender supports.

(16) With hoist lift entire assembly clear of carrier.

(17) Drain the engine crankcase and transmission oil.

(18) Disconnect all electrical leads to starter, pressure switches, and sending units.

(19) Disconnect hose assemblies to crankcase oil filter.

(20) Disconnect flexible drive cables for tachometer and speed sensing switch.

(21) Disconnect fuel return line (refer to TM 5-3810-290-12).

(22) Disconnect air lines from air compressor (refer to TM 5-3810-290-12).

(23) Disconnect the propeller shaft between the transmission and transfer case (refer to TM 5-3810-290-12).

(24) Disconnect control cable from transmission range selector valve (refer to TM 5-3810-290-12).

(25) Disconnect electrical lead to transmission solenoid valve.

(26) Disconnect and remove transmission piping as required (fig. 2-5).

(27) Attach a lifting sling to the engine lifter brackets.

(28) Remove capscrews (18 and 20, fig. 2-4), washers (15 and 27), and nuts (14 and 28) from engine mountings.

(29) Remove capscrews (13) washers (15), and nuts (14) from transmission mountings.

(30) With a suitable hoist, lift the engine and transmission assembly from the frame (1) and place on a work stand.

(31) Attach a suitable hoist to the transmission assembly.

(32) Provide access to converter drive plate hardware by removing six capscrews, lockwashers, and the access cover from the right side of the converter bell housing.

(33) Remove the twelve nuts and lockwashers securing the drive plate to the flywheel, by rotating the engine crankshaft until each becomes accessible.

(34) Remove twelve capscrews and lockwashers that secure the transmission housing to the flywheel housing.

(35) Carefully move the transmission assembly straight back from engine to avoid damage to the drive plate and mounting studs.

### c. Installation.

(1) Install the engine assembly in the reverse order of removal.

### NOTE

Install new insulators (shock mounts) (2 and 16, fig. 2-4) when replacing the assembly.

(2) Service the engine and transmission in accordance with current lubrication order.

## CHAPTER 3

## REPAIR OF CRANE AND COMPONENTS

## Section I. GENERAL

## 3-1. General

The Model H446A Crane, as described in this chapter, covers all components which are physically and functionally a part of the crane's operational capabilities. This includes the outrigger arms, and associated hydraulic cylinders and controls, but excludes the engine, carrier and associated components.

## 3-2. Crane Superstructure

The crane superstructure consists of a sub-base mounting the upper turret assembly; the ring gear and boom swing assembly; the hydraulic rotary seal; and main boom and hoist assembly; the boom head and hook block; components of the crane hydraulic system, and crane lights. Maintenance and repair may be performed on all of the above items without removal of the crane superstructure

except those parts of the boom swing assembly and the rotary seal.

## 3-3. Crane Superstructure Welding Instructions

a. Standard welding procedures can be followed when welding cracks or broken welds of crane superstructure components. The crane superstructure components, their material, and recommended welding rods are listed in table 3-1.

## NOTE

In welding large areas, do not concentrate too much in one area at one time. Partially weld one side and then alternate from side to side to avoid distortion of plates.

b. When making welds for mounting brackets, etc. to carrier main frame, use welding rod AWS-E11018 or equivalent. Proceed as in paragraph a above.

Table 3-1. Crane Superstructure Weld Rod Recommendations

| Component                  | Material    | Weld rod (* AWS) |
|----------------------------|-------------|------------------|
| Shipper plates             | V65 steel   | E7018            |
| Main boom                  | RQC60 steel | E7018            |
| Telescoping boom           | V50 steel   | E7018            |
| Boom head and extension    | EQC60 steel | E7018            |
| Anchoring device           | Mild steel  | E7018            |
| Outrigger frames           | V60 steel   | E7018            |
| Outrigger arms             | V55 steel   | E7018            |
| Brush guard                | V65 steel   | E7018            |
| Sub base                   | ASTM-A36    | E7024            |
| Top plate                  | Mild steel  | E7024            |
| Turret base plate          | Mild steel  | E7024            |
| Hydraulic oil tank support | Mild steel  | E7024            |

\* AWS—American Welders Society or equivalent.

## Section II. MAIN BOOM ASSEMBLY AND ASSOCIATED HYDRAULIC CYLINDERS

## 3-4. Boom Extension Cylinder

## a. Removal.

- (1) Disconnect tube assemblies (fig. 3-1).

- (2) Remove attaching hardware (fig. 3-1).
- (3) Remove boom extension cylinder (fig. 3-1).

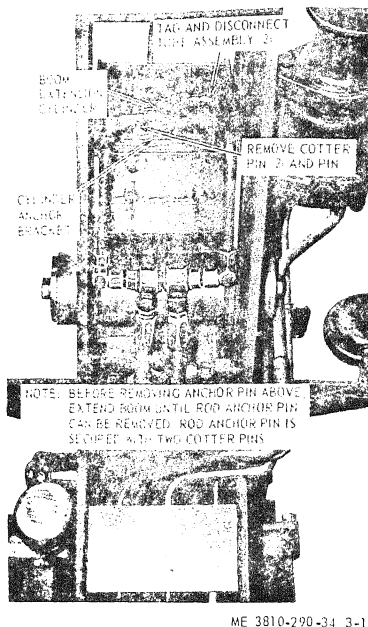


Figure 3-1. Boom extension cylinder, removal and installation.

#### b. Disassembly.

- (1) Remove the lockwire from the capscrew heads.
- (2) Remove the four capscrews (22, fig. 3-2).
- (3) Remove the head (25) and piston rod assembly from the body (13).
- (4) Remove the locknut (14), piston (15), packing (28), piston sleeve (29), piston follower (27), and packing (16).
- (5) Remove the gland (21), packing (23), bushing (24), packing (26), wiper (20), and rod (19) from the head (25).
- (6) Remove the tube assembly (11), reducer (9), packing (7 and 8), and pilot piston (6).
- (7) Remove the plug (30), packing (31), spring (32), and ball (33).

#### NOTE

Discard all used preformed packing and replace with new.

#### c. Cleaning, Inspection, and Repair.

- (1) Clean all parts with an approved cleaning solvent. Dry thoroughly with compressed air.
- (2) Inspect the piston (15), rod (19), and body (13) for scoring and wear. Remove light scoring with crocus cloth, otherwise, replace parts as required.
- (3) Inspect the head (25), gland, and rod for damaged threads.
- (4) Inspect the movement of the pilot piston (6) in the body (13). It should move freely without binding or sticking. Replace as required.

#### NOTE

Make sure the orifice in the body is thoroughly cleaned.

d. *Assembly.* Assemble the hydraulic cylinder in the reverse order of disassembly. Coat all components with clean, hydraulic fluid to lubricate and facilitate assembly. Tighten head bolts to torque of 83-93 pound-feet and secure with lockwire.

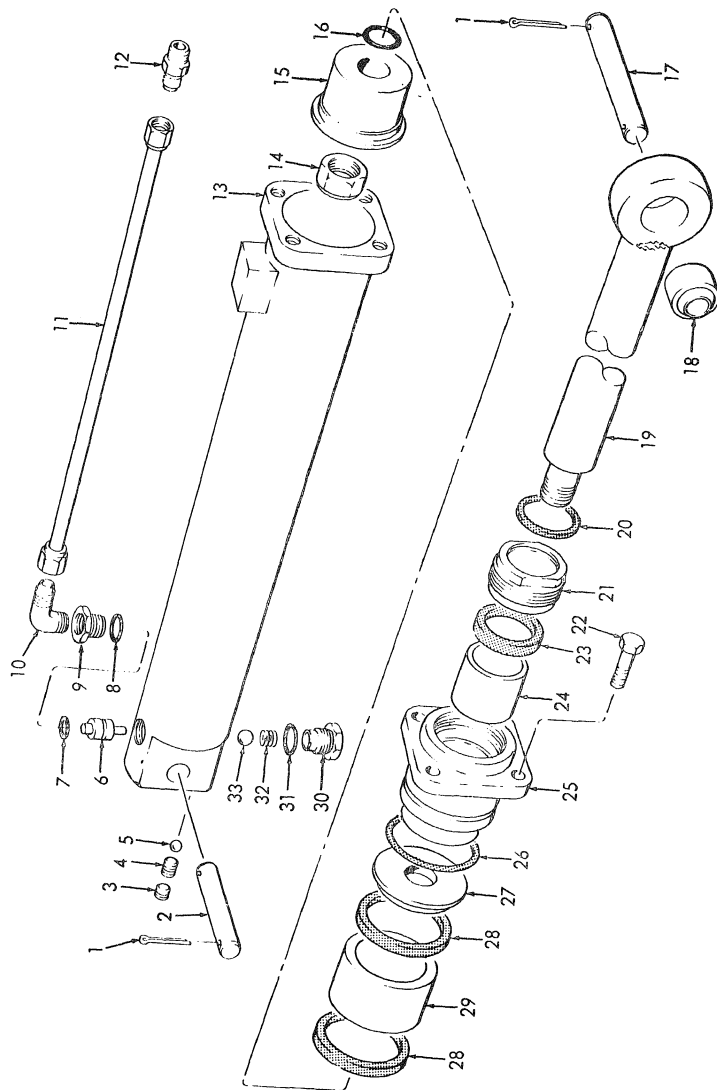
e. *Testing.* Connect the cylinder to a source of hydraulic pressure and subject the cylinder to a pressure of 2500 p.s.i. and inspect for leakage, especially in the packing gland area.

f. *Installation.* Install the boom extension cylinder in the reverse order of removal.

#### KEY to figure 3-2

1. Cotter pin
2. Pin
3. Plug
4. Screw
5. Ball
6. Pilot piston
7. Packing
8. Packing
9. Reducer
10. Elbow
11. Tube assembly
12. Connector
13. Body
14. Locknut
15. Piston
16. Packing
17. Pin
18. Bearing
19. Rod
20. Rod wiper
21. Gland
22. Capscrew
23. Packing
24. Bushing
25. Head
26. Packing
27. Piston follower
28. Packing
29. Piston sleeve
30. Plug
31. Packing





ME 3810-290-34/3-2

Figure 3-2. Boom extension cylinder, exploded view.

### 3-5. Boom Hoist Cylinders

a. *Removal.* Remove the boom hoist cylinders (refer to TM 5-3810-290-12).

b. *Disassembly.*

(1) Remove the lockwire from the capscREW heads.

(2) Remove the four capscREWS (8, fig. 3-3).

(3) Remove the head (17) and piston rod assembly from the body (9).

(4) Remove the locknut (24), piston (23), packing (20), piston sleeve (22), piston follower (19), packing (18), and head (17) from the piston rod (4).

(5) Remove the capscREWS (16), gland (14), packing (13), bushing (12), and rod wiper (15).

#### NOTE

Discard all used preformed packing and replace with new packing when assembling.

c. *Cleaning, Inspection and Repair.*

(1) Clean all parts with an approved cleaning solvent. Dry thoroughly with compressed air.

(2) Inspect the piston (23), rod (4), and body (9) for scoring and wear. Remove light scoring with crocus cloth, otherwise, replace parts as required.

(3) Inspect the rod (4) for damaged threads.

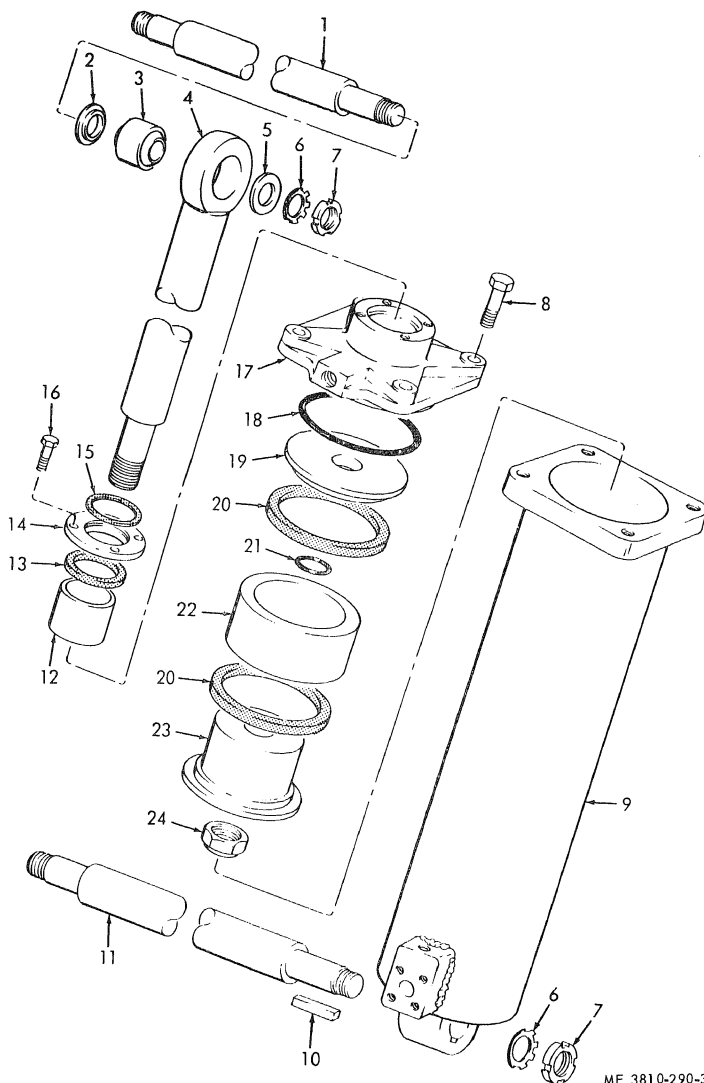
d. *Assembly.* Assemble the hydraulic cylinder in the reverse order of disassembly. Coat all components with clean, hydraulic fluid to lubricate and facilitate assembly. Tighten head bolts to torque of 475-485 pound-feet and secure with lockwire.

e. *Testing.* Connect the cylinder to a source of hydraulic pressure of 2500 p.s.i. and inspect for leaks.

f. *Installation.* Refer to TM 5-3810-290-12 and install the boom hoist cylinders.

KEY to figure 3-3.

1. Shaft
2. Spacer
3. Bearing
4. Rod
5. Washer
6. Key washer
7. Round nut
8. CapscREW
9. Body
10. Key
11. Shaft
12. Bushing
13. Packing
14. Gland
15. Rod wiper
16. CapscREW
17. Head
18. Packing
19. Piston follower
20. Packing
21. Packing
22. Piston sleeve
23. Piston
24. Locknut



ME 3810-290-34/3-3

Figure 3-3. Boom hoist cylinder, exploded view.

### 3-6. Main Boom Assembly

a. *General.* The main boom assembly consists of two components:

(1) The main boom attached to, and pivoting on the shipper plates of the upper turret.

(2) An inner or telescoping section with attached boom head, and actuated by a hydraulic cylinder.

#### b. *Removal.*

(1) Remove the hook block and hoist cable (refer to TM 5-3810-290-12).

(2) Remove the boom head assembly (refer to TM 5-3810-290-12).

(3) Disconnect the hydraulic lines to the boom extension cylinder and accessory (clamshell) circuits.

(4) Attach a sling to the main boom (32, fig. 3-4) and place a light strain on the boom with a second crane or suitable lifting device.

(5) Remove the boom hoist cylinders (refer to TM 5-3810-290-12).

(6) Remove the capscrews (1, fig. 3-4), lockwashers (2), flatwashers (3), key (5) and shaft (4).

(7) Lift the boom assembly from the shipper plates and lower to the ground.

#### c. *Disassembly.*

(1) Slide the telescoping section (24) forward and remove boom extension cylinder anchor pin (17, fig. 3-2).

(2) Remove the nuts (26, fig. 3-4) four lockwashers (27), and capscrews (28).

(3) Remove the bracket (29) and boom extension cylinder.

(4) Remove capscrews (8), lockwashers (9), centric pin (10), roller (12) and sleeve bushing (1).

(5) Remove capscrews (13), lockwashers (14), bearing retainer (18) and roller assembly (15) with bearings (17).

(6) Remove the boom hoist cylinder shaft (1, fig. 3-3).

#### d. *Cleaning, Inspection, and Repair.*

(1) Clean all parts with an approved cleaning solvent. Dry with compressed air.

(2) Inspect wear shoes (23, fig. 3-4) for wear. Replace if wear shoe bearing surface is worn to a thickness of 7/16 inch.

(3) Inspect bushings (30 and 31) for scoring or wear. If worn sufficiently to allow 0.0350" total radial clearance on the shafts or are scored, replace the bushings.

(4) Inspect the roller assembly (15) for excessive wear or damage. Replace as required.

(5) Rotate the bearings (17) slowly by hand. If roughness is detected, replace the bearing(s).

(6) Inspect the roller (12) for excessive wear or damage. Replace as required.

(7) Inspect shafts and pins for wear and scoring. Replace as required.

(8) Inspect the boom hoist cylinder shaft, on a surface plate, for warp. If longitudinal alignment varies more than 0.0250 inch, replace the shaft.

(9) Inspect main boom and telescoping section weldments for cracks, breaks, and distortion. Repair as required.

e. *Assembly.* Assemble the main boom assembly in the reverse order of disassembly.

#### f. *Installation.*

(1) Install the main boom assembly in reverse order of removal.

(2) Lubricate in accordance with current lubrication order.

#### KEY to figure 3-4.

1. Capscrew (2)
2. Lockwasher (2)
3. Washer, flat (2)
4. Shaft, straight
5. Key, machine
6. Fitting, lubrication (2)
7. Fitting, lubrication (5)
8. Capscrew
9. Lockwasher
10. Pin, eccentric
11. Bushing, sleeve
12. Roller, sleeve
13. Capscrew (8)
14. Lockwasher (8)
15. Roller assembly
16. Ring, (2) bearing, inner
17. Roll and rollers (2)
18. Retainer, bearing (2)
19. Nut (8)
20. Lockwasher (8)
21. Capscrew (6)
22. Screw, machine (2)
23. Shoe (2)
24. Boom, telescoping
25. Plug (2)
26. Nut (4)
27. Lockwasher (4)
28. Capscrew (4)
29. Bracket
30. Bushing (2)
31. Bushing (2)
32. Boom, main

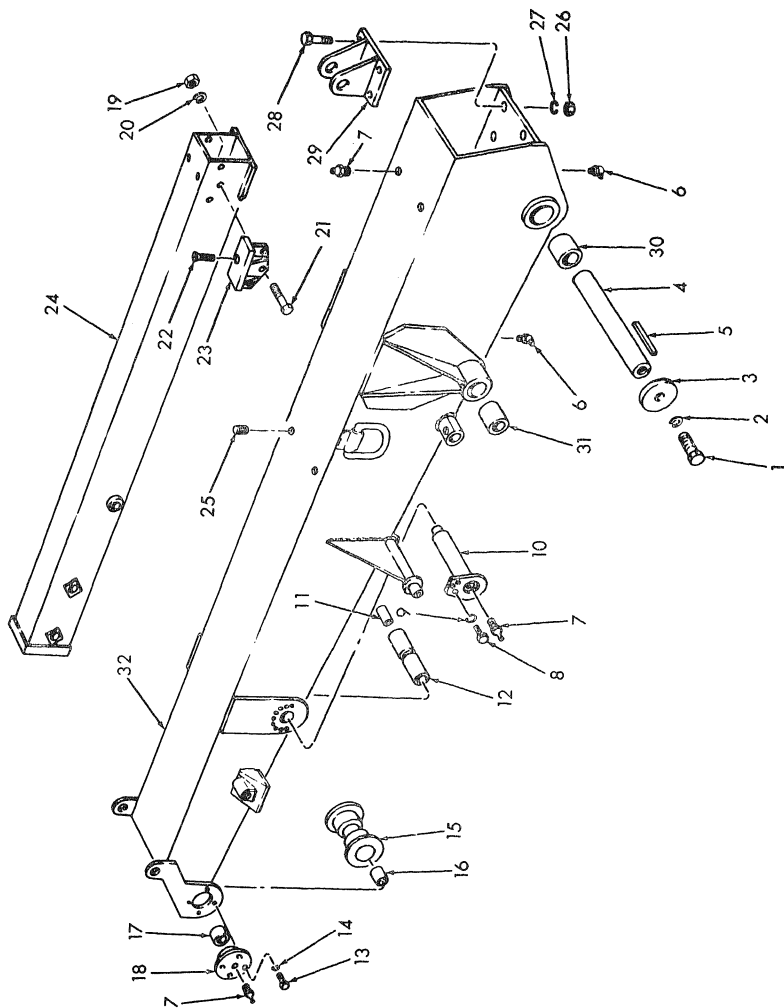


Figure 3-4. Main boom assembly, exploded view.

## Section III. HOIST DRIVE COMPONENTS

## 3-7. General

The hoist drive components consist basically of the hydraulic drive motor, and the hoist gear box and drum assembly. The hoist motor is under full power during hoisting and lowering to assure positive control of the crane load. The crane hydraulic system is connected through a rotary seal unit to the revolving hydraulic elements. The hoist gear box drive and drum assembly are sturdily constructed units, designed to provide many hours of operation under severe operating conditions.

## 3-8. Hoist Drive Motor

- a. *Removal.* Remove the hoist drive motor (refer to: TM 3810-290-121).

b. *Disassembly.*

## NOTE

Before disassembly, test motor (para f, below).

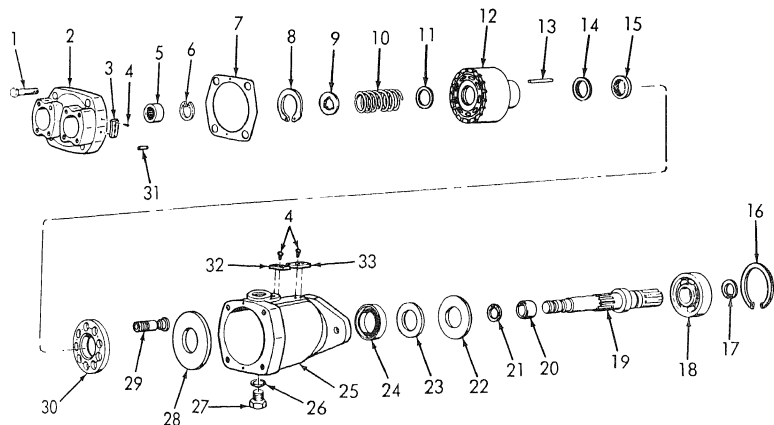
(1) Remove the four capscrews (1, fig. 3-5) from the valve plate sub-assembly (2). Remove the valve plate and gasket (7) from the housing (25).

(2) Turn the rotating group slightly to free it from the swash plate (28).

(3) Tilt the housing and remove the rotating group.

## CAUTION

Do not separate the cylinder block (12) from the rotating group during removal from the housing.



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1. Capscrew (4)
2. Valve plate
3. Rotation plate (2)
4. Screw (3)
5. Bearing
6. Retaining ring
7. Gasket \*
8. Retaining ring \*\*
9. Washer \*\*
10. Spring \*\*
11. Washer \*\*

12. Cylinder block \*\*
13. Pin (3) \*\*
14. Washer \*\*
15. Spherical washer \*\*
16. Retaining ring
17. Retaining ring
18. Bearing
19. Shaft
20. Sleeve
21. Retaining ring
22. Washer

23. Washer
24. Seal \*
25. Housing
26. Preformed packing \*
27. Plug
28. Swash plate \*\*
29. Piston / shoe assy \*\*
30. Shoe plate \*\*
31. Pin (2)
32. Instruction plate
33. Name plate

\* Included in seal kit.

\*\* Included in rotating group kit.

Figure 3-5. Hoist drive motor, exploded view.

Handle the pistons carefully to avoid marring their polished surfaces.

(5) To remove items (8 thru 11) from cylinder block (12), insert a  $\frac{1}{2}$  x  $5\frac{1}{2}$  inch long bolt with  $\frac{1}{2}$  I.D. x  $1\frac{3}{4}$  O.D. flat washer through shaft bore. Place another flat washer and nut on bolt and tighten until tension is removed from retaining ring (8).

(6) Remove retaining ring (8) and back off nut slowly to relieve compression on spring (10). Remove spring (10) and washers (9 and 11).

(7) Lift the swash plate (28) from the housing.

(8) Remove the retainer ring (16).

(9) Drive the shaft (19) and bearing (18) from the housing with a soft tip hammer.

(10) Remove the retainer ring (17), and bearing (18) from the shaft.

(11) Remove the retainer (21) and sleeve (20) from the shaft (19).

(12) Remove the washers (22 and 23) and seal (24) from the housing.

#### *c. Cleaning, Inspection, and Repair.*

(1) Clean all parts with an approved solvent. Dry thoroughly and place on a clean surface for inspection.

(2) Inspect the valve plate (2) for wear or scoring on the flat surface which mates with the cylinder block (12). Minor defects can be removed by lightly stoning the surface, however, any lapping should not exceed 0.0002 inch. If damage requires more lapping, replace the valve plate.

(3) Inspect the cylinder block (12) for wear and scoring of bores and surface that mates with valve plate (2). Minor scoring of the flat surface can be removed with a fine lapping stone. Replace a cylinder block that has damaged bores, or is deeply scored.

#### **NOTE**

A rotating group kit and a seal kit are available for the repair of the motor. Refer to TM 5-3810-290-34P for kit components.

(4) Replacement of all nine piston and shoe assemblies (29) is recommended at overhaul. The ball must swivel smoothly in shoe and end play between piston and shoe must not exceed 0.003 inch. The dimension of the shoe shoulder from the shoe face that rides on the swash plate must be maintained within 0.001 inch from one shoe to another for all nine shoes. If necessary, hand lap the shoes using a 400A or 500A emery paper backed by a lapping plate.

(5) Inspect the swash plate (28) for wear or scoring. Minor defects may be removed with a lapping stone. If removal of more than 0.0004 inch is required, replace swash plate.

(6) Inspect the bearings (5 and 18) for roughness or excessive play. Replace if necessary.

(7) Inspect the drive shaft (19) for scoring or wear in the shaft seal (24) area. Replace shaft if scored or worn.

*d. Assembly.* Assembly is basically the reverse of disassembly but extreme care should be exercised in assembly to insure correct performance. Use a new gasket (7), seal (24), and packing (26) when assembling.

(1) Coat all parts with a light film of clean hydraulic fluid.

(2) Install a new shaft seal (24) in the housing (25) with seal driver (fig. 3-1). Place washers (22 and 23) over the seal.

(3) Install bearing (18) and retainer ring (17) on the drive shaft (19). Fill the bearing one-third full with a good grade of high temperature ball bearing grease. Install the shaft and bearing in the housing and install retainer ring (16).

(4) Assemble ring (8), washers (9 and 11), and spring (10) in cylinder block (12).

(5) Install the swash plate (28) in housing with chamfered edge facing shaft seal.

(6) Place the cylinder block face down on a smooth clean surface. Insert the three pins (13) in the cylinder block (12). Grease washer (14) and spherical washers (15) and place them on the pins.

(7) Place the nine pistons (29) in the shoe plate (30).

#### **CAUTION**

**Do not allow the pistons to strike each other.**

(8) Hold the shoe plate carefully and align the pistons and slip them into the lubricated cylinder block.

(9) Hold the cylinder block and shoe plate carefully to keep the pins and washers, and other components intact; install the rotating group on the drive shaft. Rotate slightly to aid in aligning splines of cylinder body and drive shaft.

(10) Replace valve plate (2) and gasket (7). Secure with capscrews (1) and tighten to a torque of 90-95 pound-feet.

#### *e. Performance Testing.*

(1) Mount the hydraulic hoist motor on a

suitable bench where it is possible to make the following hook-up:

(a) Adapt a brake-load cell to motor shaft, capable of indicating 0 to 3600 in-lb. running torque.

(b) Provide a hydraulic fluid supply, so that: rate of flow can be metered from 0 to 80 GPM; and the supply pressure is variable from 0 to 3000 p.s.i.

(c) Adapt a tachometer to motor shaft, with a range of 0 to 3200 RPM.

(2) With the brake-load cell set at each of the following listed in-lbs. running torque, the approximate pressure required for operation of the motor is indicated.

| In-lbs. | Differential input pressure |
|---------|-----------------------------|
| 500     | 650-700                     |
| 1000    | 1200-1250                   |
| 1500    | 1750-1800                   |
| 2000    | 2300                        |
| 2500    | 2850                        |

#### NOTE

Initial pressure required for starting can be 25 percent higher than shown.

(3) With a tachometer mounted on the motor shaft, supply hydraulic fluid to the motor at each of the following listed rates, observing the corresponding output RPM indicated on tachometer.

| GPM | RPM  |
|-----|------|
| 10  | 400  |
| 20  | 790  |
| 30  | 1185 |
| 40  | 1585 |
| 50  | 1975 |
| 60  | 2375 |
| 70  | 2770 |

(4) Failure of motor to meet the above performance characteristics within a 10 percent tolerance indicates a faulty motor and replacement is required.

#### f. Leakage Test.

(1) Provide a 120° F. oil supply at 3000 p.s.i.

(2) Drive the hoist motor at a constant speed between 100-2000 RPM.

(3) Provide a means of measuring the rate of flow from motor case drain.

(4) Maximum allowable drainage is 10,000 cubic centimeters per minute. If rate of flow exceeds this, repair or replace motor.

g. Installation. Refer to TM 5-3810-290-12. Install the hoist motor.

### 3-9. Hoist Gear Box and Drum Assembly

#### a. Removal.

(1) Remove hoist gear box and drum assembly.

(2) Remove the hoist drive motor (refer to TM 5-3810-290-12).

#### b. Disassembly.

(1) Remove capscrews (31, fig. 3-6), lockwashers (30), and cover plate (29).

(2) Remove the capscrews (35), lockwashers (36), and cover (27).

(3) Loosen the jam nut (9), and remove the setscrew (8).

(4) Remove the center plate (10), and worm gear (25) from the shaft.

(5) Remove the capscrews (1), retainer (3), and gasket (4).

(6) Remove plug (59), setscrew (17), and coupling (16).

(7) Remove the capscrews (19), lockwashers (20), motor adapter (21), and gasket (22) from the gear case.

(8) Remove the shaft (14), spacer (7 and 12), and worm (11) from the gear box.

#### c. Cleaning, Inspection, and Repair.

(1) Clean all parts with an approved solvent. Dry thoroughly.

(2) Inspect the shaft (14) for scoring and wear.

(3) Inspect the bushing (28) for scoring and excessive wear. If radial clearance on drum shaft bushings exceeds 0.010 inch, replace the bushings.

(4) Inspect the bronze worn gear teeth (25) for excessive wear by meshing the steel worm (11) with the worm gear. If backlash between worm and gear exceeds 0.025 inch, replace the worm gear (25) on the center plate (10), by removing the capscrews (37) and lockwashers (38). When replacing the worm gear, tighten capscrews to 50-55 ft.-lbs. torque.

(5) Inspect the steel worm for scoring. Replace as required.

(6) Inspect the tapered roller bearings (24) for worn rollers and rough spots while rotating the bearings. Inspect the bearing cup (23), for rough spots. Replace as required.

(7) Inspect the keys (13 and 15) for wear. If any are loose fitting in respective keyways, replace.

(8) Remove the seal (18) from the motor adapter (21). Replace with new seal when assembling the unit.

d. Assembly. Assemble gear case and drum assembly in reverse order of disassembly. Replace gaskets (22 and 4) with new units.

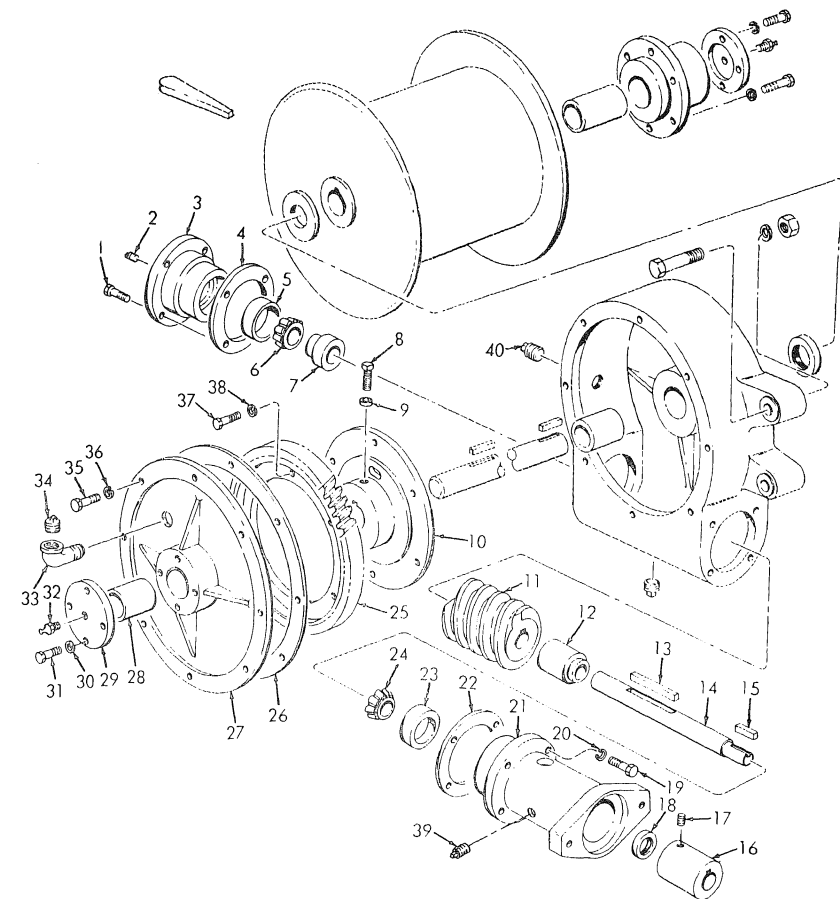
#### e. Installation.

(1) Refer to TM 5-3810-290-12, and install the hoist gear box and drum assembly.

(2) Refer to TM 5-3810-290-12 and install the hoist drive motor.

(3) Lubricate the gear box assembly in ac-





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- |                   |                    |                    |                          |
|-------------------|--------------------|--------------------|--------------------------|
| 1. Capscrew (4)   | 11. Worm           | 21. Adapter, motor | 31. Capscrew (4)         |
| 2. Plug, pipe     | 12. Spacer         | 22. Gasket         | 32. Fitting, lubrication |
| 3. Retainer       | 13. Key            | 23. Cup, bearing   | 33. Elbow                |
| 4. Gasket         | 14. Shaft          | 24. Cone, bearing  | 34. Plug, pipe           |
| 5. Cup, bearing   | 15. Key            | 25. Gear, worm     | 35. Capscrew (8)         |
| 6. Cone, bearing  | 16. Coupling       | 26. Gasket         | 36. Lockwasher (8)       |
| 7. Spacer         | 17. Setscrew       | 27. Cover          | 37. Capscrew (6)         |
| 8. Setscrew (2)   | 18. Seal           | 28. Bushing        | 38. Lockwasher (6)       |
| 9. Washer (2)     | 19. Capscrew (6)   | 29. Cover plate    | 39. Plug                 |
| 10. Plate, center | 20. Lockwasher (6) | 30. Lockwasher (4) | 40. Plug, pipe           |

Figure 3-6. Hoist gear box and drum assembly, exploded view.

## Section IV. UPPER TURRET AND BOOM SWING COMPONENTS

### 3-10. General

The crane sub-base and superstructure assembly must be removed from the carrier before the boom swing motor, boom swing gear box, rotary seal, and upper turret can be removed (fig. 3-7). The boom swing motor is similar in design with the hoist drive motor. The boom swing gear box is also similar in design with the hoist gear box (para 3-9). The rotary seal unit and collector ring assembly provides hydraulic and electric connections to the superstructure revolving elements.

### 3-11. Boom Swing Motor

*a. Removal.* Remove the boom swing motor (refer to TM 5-3810-290-12).

#### NOTE

Before disassembly, test motor (para f, below).

#### *b. Disassembly.*

(1) Remove the four capscrews (1, fig. 3-8) from the valve plate subassembly (2). Remove the valve plate (2) and gasket (6) from the housing (21).

(2) Turn the rotating group slightly to free it from the swash plate (24).

(3) Tilt the housing and remove the rotating group.

### CAUTION

Do not separate the cylinder block (11) from the rotating group during removal from the housing.

(4) Remove the pistons (25) and shoe plate (26) from the cylinder block (11).

### CAUTION

Handle the pistons carefully to avoid marring their polished surfaces.

(5) To remove items (7 thru 10) from cylinder block (11), insert a  $\frac{3}{8}$  x 5 inch long bolt with  $\frac{3}{4}$  I.D. x  $1\frac{1}{2}$ " O.D. flat-washer through shaft bearing (15). Place another flat washer and nut on bolt and tighten until tension is removed from retaining ring (7).

(6) Remove retaining ring (7) and back nut slowly to relieve compression on spring (9). Remove spring (9) and washers (8 and 10).

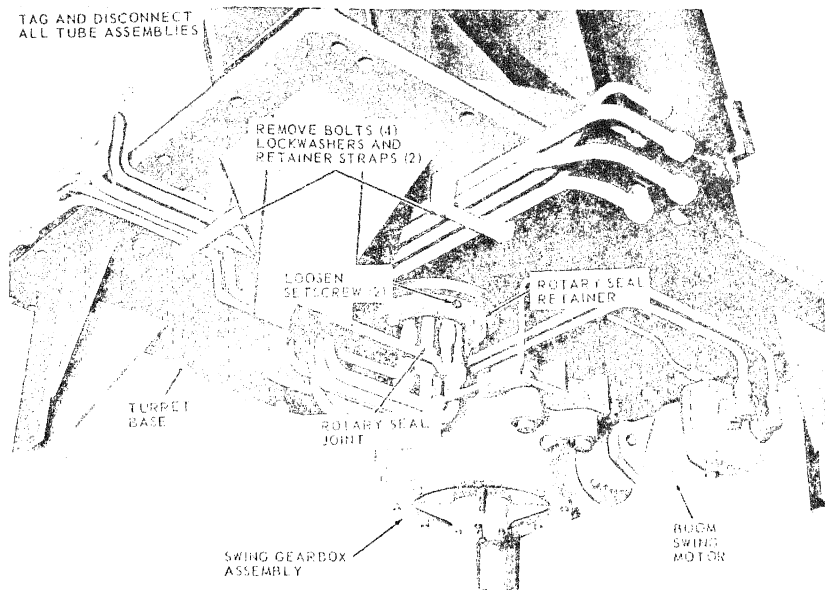
(7) Lift the swash plate (24) from the housing.

(8) Remove the retainer ring (16).

(9) Drive the shaft (15) and bearing (11) from the housing with a soft tip hammer.

(10) Remove the retainer ring (17), a bearing (18) from the shaft.

(11) Remove the washer (19) and seal (2) from the housing.



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Figure 3-7. Rotary seal and tubing, disconnect, removal, and installation.

### c. Cleaning, Inspection, and Repair.

(1) Clean all parts with an approved solvent. Dry thoroughly and place on a clean surface for inspection.

(2) Inspect the valve plate (2) for wear or scoring on the flat surface which mates with the cylinder block (11). Minor defects can be removed by lightly stoning the surface, however, any lapping should not exceed 0.0002 inch. If damage requires more lapping, replace the valve plate.

(3) Inspect the cylinder block (11) for wear and scoring of bores and surface that mates with valve plate (2). Minor scoring of the flat surface can be removed with a fine lapping stone. Replace a cylinder block that has damaged bores, or is deeply scored.

### NOTE

A rotating group kit and a seal kit are available for the repair of the motor. Refer to TM5-3810-290-34P for kit components.

(4) Replacement of all nine piston and shoe assemblies (25) is recommended at overhaul. The ball must swivel smoothly in shoe and end play between piston and shoe must not exceed 0.003 inch. The dimension of the shoe shoulder from the shoe face that rides on the swash plate must be maintained within 0.001 inch from one shoe to another for all nine shoes. If necessary, hand lap the shoes using a 400A or 500A emery paper backed by a lapping plate.

### NOTE

Dip emery paper in kerosene and keep wet during polishing.

(5) Inspect the swash plate (24) for wear or scoring. Minor defects may be removed with a lapping stone. If removal of more than 0.004 inch is required, replace swash plate.

(6) Inspect the bearings (5 and 18) for roughness or excessive play. Replace if necessary.

(7) Inspect the drive shaft (15) for scoring or

wear in the shaft seal (20) area. Replace shaft if scored or worn.

*d. Assembly.* Assembly is basically the reverse of disassembly but extreme care should be exercised in assembly to insure correct performance. Use a new gasket (6), seal (20), and packing (23) when assembling.

(1) Coat all parts with a light film of clean hydraulic fluid.

(2) Install a new shaft seal (20), in the housing (21), with seal driver (fig. 2-1). Place washer (19) over the seal.

(3) Install bearing (18) and retainer ring (17), on the drive shaft (15). Fill the bearing one-half full with good grade of high temperature ball bearing grease. Install the shaft and bearing in the housing and install retainer ring (16).

(4) Assemble ring (7), washers (8 and 10), and spring (9) in cylinder block (11).

(5) Install the swash plate (24) in housing with chamfered edge facing shaft seal.

(6) Place the cylinder block (11) face down on a smooth, clean surface. Insert the three pins (12) in the cylinder block (11). Grease the back-up washer (13) and spherical (14) washers and place them on the pins.

(7) Place the nine pistons (25) in the shoe plate (26).

### CAUTION

Do not allow the pistons to strike each other.

(8) Hold the shoe plate carefully and align the pistons and slip them into the lubricated cylinder block.

(9) Hold the cylinder block and shoe plate carefully to keep the pins and washers, and other components intact; install the rotating group on the shaft. Rotate slightly to aid in aligning splines in cylinder body and drive shaft.

(10) Replace valve plate (2) and gasket (6). Secure with capscrews (1) and tighten to a torque of 70-80 pound-feet.

### *e. Performance Testing.*

(1) Mount the hydraulic swing motor on a suitable bench and provide the hook-up outlined in paragraph 3-8 e (1) for the hoist motor.

(2) With the brake load cell set at each of the

following listed in.-lbs. running torque, the approximate pressure required for operation of the motor is indicated.

| <i>In-lbs.</i> | <i>Differential input pressure</i> |
|----------------|------------------------------------|
| 500 .....      | 950                                |
| 1000 .....     | 1850-1900                          |

### NOTE

Initial pressure required for starting can be 25 percent higher than shown.

(3) With a tachometer mounted on the motor shaft, supply hydraulic fluid to the motor at each of the following listed rates, observing the corresponding output RPM indicated on the tachometer.

| <i>GPM</i> | <i>RPM</i> |
|------------|------------|
| 10 .....   | 550        |
| 20 .....   | 1190       |
| 30 .....   | 1800       |
| 40 .....   | 2400       |

### KEY to figure 3-8.

1. Capscrew (4)
2. Valve plate
3. Rotation plate
4. Screw (6)
5. Bearing
6. Gasket \*
7. Retainer \*\*
8. Washer \*\*
9. Spring \*\*
10. Washer \*
11. Cylinder block \*\*
12. Pin (3) \*\*
13. Washer \*\*
14. Spherical washer \*\*
15. Shaft
16. Retainer
17. Retainer
18. Bearing
19. Washer
20. Seal \*
21. Housing
22. Plug
23. Preformed packing \*
24. Swash plate \*\*
25. Piston (9) \*\*
26. Shoe plate \*\*
27. Pin (2)
28. Instruction plate
29. Nameplate

\* Included in seal kit.

\*\* Included in rotating group kit.

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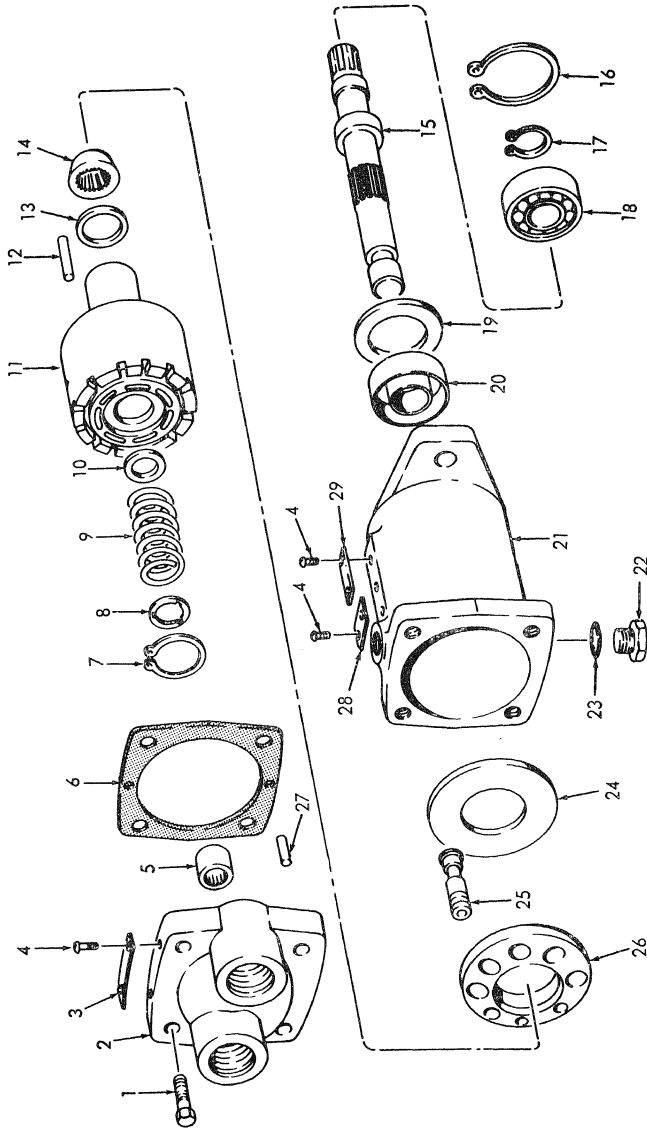


Figure 3-8. Boom swing motor, exploded view.

(4) Failure of motor to meet the above performance characteristics within a 10 percent tolerance indicates a faulty motor and replacement is required.

*f. Leakage Test.*

- (1) Provide a 120° F. oil supply at 3000 p.s.i.
- (2) Drive the motor at a constant speed between 100-2600 rpm.
- (3) Provide a means of measuring the rate of flow from motor case drain.
- (4) Maximum allowable drainage is 6,430 cubic centimeters per minute. If rate of flow exceeds this, repair or replace motor.

*g. Installation.* Refer to TM 5-3810-290-12 and install the boom swing motor.

**3-12. Boom Swing Gear Box**

*a. Removal.* Remove boom swing gear box (refer to TM 5-3810-290-12).

*b. Disassembly.*

- (1) Remove pinion gear (19, fig. 3-9), thrust washer (18), key (11), and bearing (16), from shaft (22).
  - (2) Remove capscrews (41), lockwashers (40), and cover (39).
  - (3) Remove capscrews (44), lockwashers (45), gasket (36), and cover (37).
  - (4) Loosen jam nut (9) and setscrew (8).
  - (5) Remove the worm gear (35) and center plate (34) from shaft (22). Remove key (10) and shaft (22).
  - (6) Remove the capscrews (1), closed end plug (3), and gasket (4).
  - (7) Remove plug (48), setscrew (29), and coupling (28).
  - (8) Remove the capscrews (31), lockwashers (2), motor adapter (33) and gasket (4).
  - (9) Remove seal (30) from motor adapter and al (17) from gear case (13).
  - (10) Remove bearing cones (6), spacers (7 and 24), worm (23), and key (26), from shaft (25).
  - (11) With suitable puller, remove bearing cups (5) from end plug (3) and motor adapter (33).
- c. Cleaning, Inspection, and Repair.*
- (1) Clean all parts with an approved solvent. Dry thoroughly.
  - (2) Inspect the shafts (22 and 25) for scoring and wear.
  - (3) Inspect the bushings (21 and 38) for scoring and excessive wear. If ply on drive pinion shaft (22) exceeds 0.015-0.025 inch, replace the bushings.
  - (4) Inspect the bronze worm gear teeth for excessive wear. Check the wear by meshing the steel worm (23) with worm gear. If end play on worm shaft exceeds 0.020 inch, replace the worm

gear on the center plate (34) by removing the nu (49), lockwashers (47), and capscrews (46). When replacing the worn gear, tighten nuts to 50-55 pound-feet. torque.

(5) Inspect the steel worm for scoring. Replace as required.

(6) Inspect the tapered roller bearing (6) for worn rollers and rough spots while rotating the bearings. Inspect the bearing cup (5) for rough spots. Replace as required.

(7) Inspect the keys (10, 11, 26, and 27) for wear. If any are loose fitting in respective keyways, replace.

(8) Inspect the thrust washer (18) for scoring and wear. Minimum thickness is 0.225 inch. Replace as required.

*d. Assembly.* Assemble the gear case assembly in the reverse order of disassembly. Replace seals (1' and 30) and gasket (4) with new units.

*e. Installation.* Refer to TM 5-3810-290-12 and install the gear box assembly and swing motor.

**KEY to figure 3-9.**

- |                     |                    |
|---------------------|--------------------|
| 1. Capscrew (4)     | 25. Shaft          |
| 2. Pipe plug        | 26. Key            |
| 3. Closed end plug  | 27. Key            |
| 4. Gasket (2)       | 28. Coupling       |
| 5. Bearing cup (2)  | 29. Setscrew       |
| 6. Bearing cone (2) | 30. Seal           |
| 7. Spacer           | 31. Capscrew       |
| 8. Setscrew (2)     | 32. Lockwasher     |
| 9. Jam nut (2)      | 33. Motor adapter  |
| 10. Key             | 34. Center plate   |
| 11. Key             | 35. Worm gear      |
| 12. Plug            | 36. Gasket         |
| 13. Gear case       | 37. Cover          |
| 14. Capscrew (4)    | 38. Bushing        |
| 15. Lockwasher (4)  | 39. Cover          |
| 16. Bearing         | 40. Lockwasher (4) |
| 17. Seal            | 41. Capscrew (4)   |
| 18. Thrust washer   | 42. Pipe plug      |
| 19. Pinion gear     | 43. Plug           |
| 20. Pipe plug       | 44. Capscrew (8)   |
| 21. Bushing         | 45. Lockwasher (8) |
| 22. Shaft           | 46. Capscrew (6)   |
| 23. Worm            | 47. Lockwasher (6) |
| 24. Spacer          | 48. Plug           |
|                     | 49. Nut (6)        |

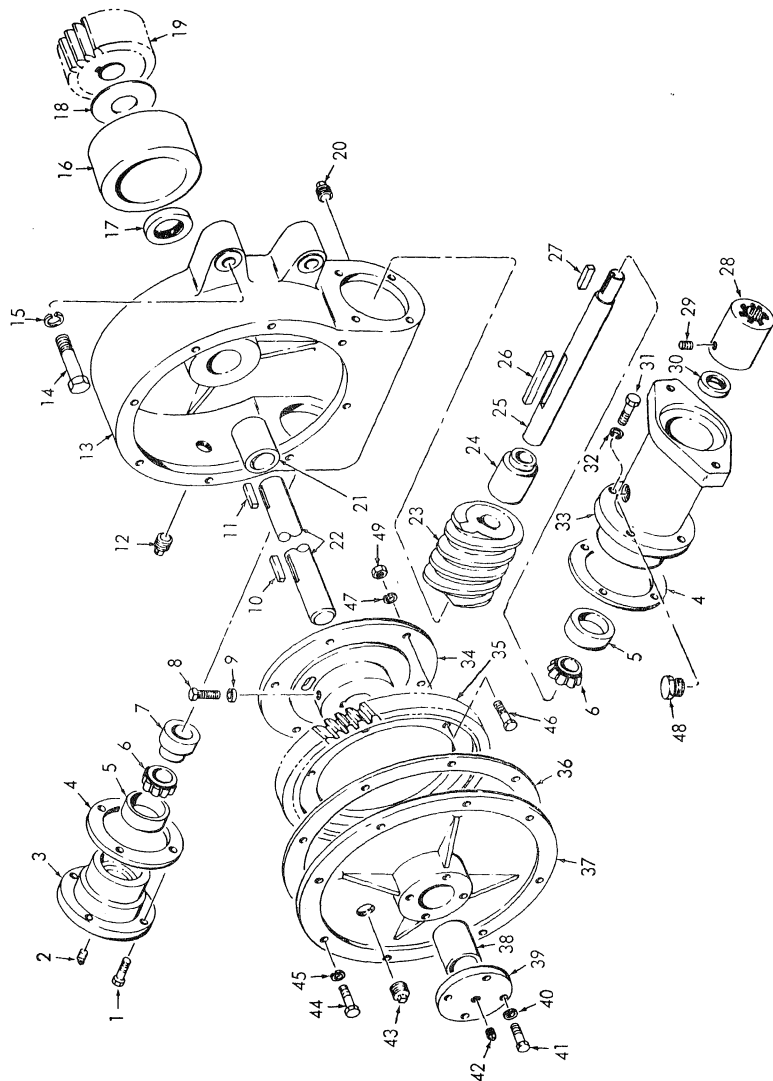


Figure 3-9. Boom swing gear box assembly, exploded view.

### 3-13. Rotary Seal Assembly

#### a. Removal.

- (1) Disconnect and remove the crane superstructure (refer to TM 5-3810-290-12).
- (2) Disconnect the hydraulic lines connected to the base of the rotary seal (fig. 3-7).

#### NOTE

When removing tube assemblies, tag assemblies to facilitate installation at assembly.

- (3) Loosen setscrews (14, fig. 3-10), and remove lock collar (13).
- (4) Remove collector ring assembly (refer to TM 5-3810-290-12).
- (5) Disconnect eight hydraulic lines from fittings of rotary seal housing (4). Disconnect one hydraulic line from top of rotary seal and remove the through tube assembly.
- (6) Remove rotary seal assembly.

#### b. Disassembly.

#### CAUTION

Do not attempt to reseat or overhaul a rotary seal which has "locked up". Internal spool and housing damage will prohibit repair.

- (1) Remove screw (1, fig. 3-10) and cover plate (2).
- (2) Remove and discard packing (3).
- (3) Remove screws (15), and retaining ring (12).
- (4) Press spool assembly (10) out of flange end of housing (4).
- (5) Place spool on a clean cloth on a smooth wood surface, and remove lower bearing (11).
- (6) Remove upper bearing (7) from housing.
- (7) Remove and discard seals (8) and packing (9).

#### c. Cleaning, Inspection, and Repair.

- (1) Clean all metal parts with an approved cleaning solvent. Dry thoroughly with compressed air.
- (2) Inspect all hydraulic fittings on the rotary seal housing (4) for damaged threads. Replace fittings and/or seal assembly as required.
- (3) Carefully clean the spool and housing and dry thoroughly with a lint free cloth.
- (4) Lubricate spool and housing with clean hydraulic oil.
- (5) Clean bearings.
- (6) Inspect bearings for binding or roughness.
- (7) Lubricate bearings with clean hydraulic oil.

#### d. Assembly.

- (1) Install new packing (9) and seal (8) in each of the nine slots of the spool (10).

#### NOTE

It is necessary to install the packings and seals from the top of the spool. Work them over the spool, and install the bottom packing and seal first. Work toward the top until all nine of the packings and seals are installed on the spool.

- (2) Align the spool and housing; compress the top seal, and work the spool into the housing.

#### CAUTION

Scratches or abrasions on the teflon seals will be potential sources of leaks. Entry of the spool into the housing must be made gradually with a small amount of rotation.

- (3) Repeat procedure (2) above for each seal and packing in succession until the spool is completely inserted in the housing.
- (4) Install upper and lower bearings (7 and 11) with open side of bearing facing spool.

#### NOTE

It is necessary to have open side of bearings facing spool to accomplish lubrication of the ball bearings.

- (5) Install cover plate (2) and retaining ring (12) with new packing (3).
- (6) Continue assembly of rotary seal in reverse order of disassembly.

#### e. Installation.

- (1) Refer to TM 5-3810-290-12 and install the collector ring assembly.
- (2) Install rotary seal assembly with port number 4 positioned on right side, 90° from the longitudinal axis.
- (3) Install lock collar (13) and secure it in place with setscrew (14).
- (4) Insert through tube assembly, and connect one hydraulic line to top of tube assembly.
- (5) Connect eight hydraulic lines to the eight fittings on rotary seal housing.
- (6) Install tube assemblies to base of rotary seal using tags for positioning, or as follows:
  - (a) Install reducing tee on through tube

#### NOTE

Port numbers are stamped on base of rotary seal.

- (b) Connect tube assembly (part no. 54324) to port number 5, finger tight.
- (c) Connect tube assembly (part no. 54322) to port number 3.

#### NOTE

Tube assemblies must be stacked in tube retainer (fig. 3-6) during assembly.

- (d) Connect tube assembly (part no. 54323) to port number 4.



(e) Connect tube assembly (part no. 54321) to port number 2.

(f) Connect tube assembly (part no. 54320) to port number 1.

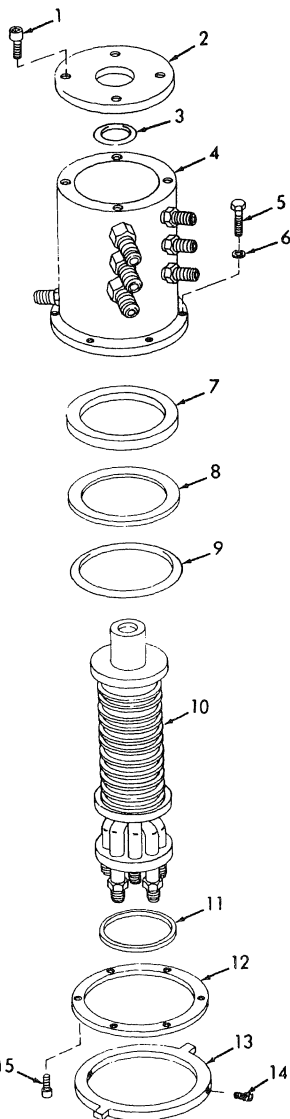
(g) Connect tube assembly (part no. 54326) to port number 7.

(h) Loosen tube assembly on port number 5. Connect tube assembly (part no. 54327) to port number 8. Tighten tube assembly on port number 5.

(i) Connect drain line tube assemblies to tee on through tube.

(j) Install retainer straps.

(k) Install wire assembly through rotary seal and connect to collector ring.



#### KEY to figure 3-10

1. Screw (4), internal hexagon filister head
2. Plate, cover
3. Packing, preformed
4. Housing
5. Capscrew (3), hexagon head
6. Lockwasher (3)
7. Bearing, ball
8. Seal (9), teflon
9. Packing preformed
10. Spool assembly
11. Bearing, ball
12. Ring retaining
13. Lock collar
14. Setscrew, square head
15. Screw (6), internal hexagon filister head

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Figure 3-10. Rotary seal assembly.

### 3-14. Upper Turret Assembly

#### a. Removal.

- (1) *Disconnect and remove the crane superstructure (refer to TM 5-3810-290-12).*

#### NOTE

Removal of the hook block, main boom, and hoist drive and drum is not mandatory, but may be desirable because of lessened weight and greater ease in handling. For removal of hook block and hoist drive and drum, refer to paragraph 3-6.

- (2) Remove the collector ring assembly (refer to TM 5-3810-290-12).

- (3) Remove the rotary seal assembly (para 3-13).

- (4) Remove the boom swing motor and boom swing gear drive assembly (para 3-11 and 3-12).

#### b. Disassembly.

- (1) Attach a sling and suitable lifting device to upper turret assembly (30, fig. 3-11).

- (2) Remove capscrews (26) and lockwashers (28), that secure antirotation lock (29) to ring gear bearing (31), and remove lock with lubrication fitting (16), chain (17), and turret lock pin (18).

- (3) Remove capscrews (27), and lockwashers (28), that secure upper turret (30) and ring gear bearing to top plate (32), and remove upper turret assembly.

- (4) Remove ring gear bearing (31).

#### NOTE

This ring gear bearing is a precision manufactured item, and its removal is not required unless inspection reveals badly scored or broken gear teeth, or binding in the rotation of the assembly. Do not attempt to repair. Replace the assembly if required.

#### c. Cleaning, Inspection, and Repair.

- (1) Clean all parts with an approved cleaning solvent. Dry thoroughly with compressed air.

- (2) Remove all rust and scaling paint with a stiff wire brush and abrasive cloth. Paint all exterior bare metal surfaces before assembling the unit.

- (3) Inspect the boom hoist cylinder shaft for radial play in bushings (13). If play exceeds 0.030 inch, replace the bushing.

- (4) Install the boom swing gear box (para 3-12) and measure the backlash between drive pinion and ring gear. Normal backlash is 0.015 to 0.023 inch. If backlash exceeds 0.050 inch, replace the drive pinion and/or ring gear.

- (5) Replace the lubrication fittings (14, and 16) as required.

#### d. Assembly.

- (1) Install the ring gear bearing (31) in plate (32).

- (2) Coat the ring gear and drive pinion teeth with gear lubricant (refer to LO 5-3810-290-1).

- (3) Install the upper turret assembly on ring gear bearing.

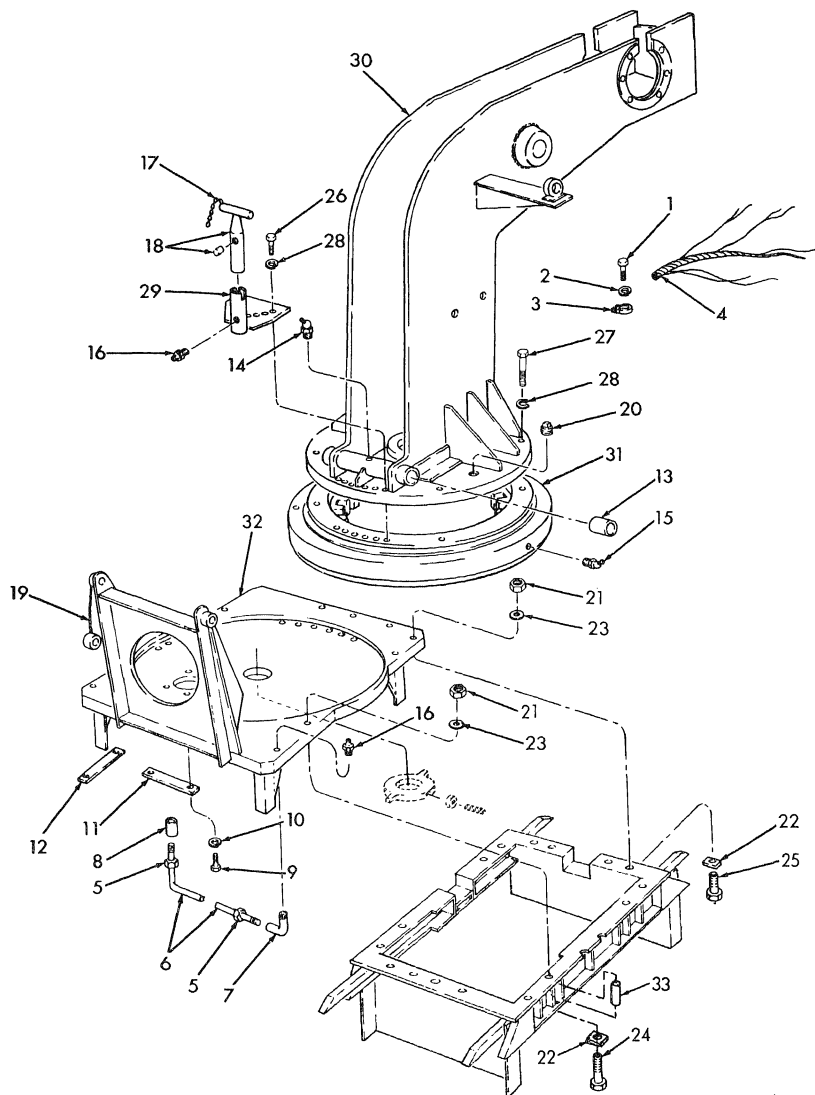
- (4) Install antirotation lock on upper turret assembly.

- (5) Secure upper turret assembly and antirotation lock with capscrews (26 and 27), and lockwashers (28).

- (6) Torque capscrews to 240-250 pound-feet.
- e. *Installation. Install the upper turret assembly in reverse order of removal.*

#### KEY to figure 3-11.

1. Capscrew (31)
2. Lockwasher (31)
3. Clamp, loop (3)
4. Harness, wire
5. Nut, tube coupling (2)
6. Tube, copper
7. Elbow, pipe
8. Connector, straight
9. Capscrew (4)
10. Lockwasher (4)
11. Bracket
12. Bracket
13. Bushing, sleeve (2)
14. Fitting, lubrication
15. Fitting, lubrication
16. Fitting, lubrication (2)
17. Chain
18. Pin, lock
19. Collar (2)
20. Plug, pipe
21. Nut (16)
22. Washer, bevel (16)
23. Washer (16)
24. Capscrew (8)
25. Capscrew (8)
26. Capscrew (6)
27. Capscrew (10)
28. Lockwasher (16)
29. Lock, antirotation
30. Upper turret assembly
31. Bearing, ring gear
32. Plate, top
33. Spacer (8)



## Section V. CRANE HYDRAULIC SUPPLY SYSTEM

## 3-15. General

a. The heart of the crane hydraulic system consists of the reservoir with adequate capacity, external return line filter, hydraulic pump, and associated lines and fittings connected to the actuating components of the crane. Replacement of the reservoir and associated components has been covered in TM 5-3810-290-12.

b. The crane hydraulic pump is a dual, rotary vane, high-pressure unit mounted on the carrier frame at the rear, and driven by the engine crankshaft through an adapter bolted to the crankshaft pulley, a flexible coupling, and a reduction gear box. The pump supplies all fluid power required for crane operations.

## 3-16. Crane Hydraulic Pump

a. **Removal.** Remove the pump assembly (refer to TM 5-3810-290-12).

b. **Disassembly.**

- (1) Clamp the pump body (25, fig. 3-12), in a vise with protective jaw covering, cover end up.
- (2) Remove the four cover bolts (1).
- (3) Mark the cover (2) and inlet housing (17) to insure correct port positioning during assembly.
- (4) Remove the cover (2) and packing (7).
- (5) Pull out the end cartridge.
- (6) Remove four bolts (16).
- (7) Remove inlet housing (17) and packing (38).
- (8) Turn shaft (30) to free large cartridge and remove cartridge from body (25).
- (9) Remove large locking (33) and pull out shaft (30) and bearing (31)

## NOTE

If it is necessary to remove the shaft bearing (31), remove the retainer (32). Press the shaft out of the bearing, supporting the inner bearing race.

- (10) Drive out shaft seal (27) and wiper (26) from the body (25).
- (11) Remove the preformed packing (35 and 36) and back-up rings (34 and 37) from the pressure plate (39).
- (12) Remove the two fillister-head screws (18) and lift off the wear plate (20).

## CAUTION

- Note carefully the position of the ring (21), rotor (22), and vanes (24) to insure proper positioning when reassembling.
- (13) Repeat the above procedure in disassembling the wear plate (13) and pressure plate (8).
  - (14) Separate the rings, rotors, vanes, locating pins, and pressure plates.

(15) Discard shaft seal, preformed packing, and back-up rings. *Use a new seal kit when assembling the pump.*

c. **Cleaning, Inspection, and Repair.**

- (1) Wash all metal parts in clean, cleaning solvent. Dry thoroughly with filtered compressed air.
- (2) Place all parts on a clean surface for inspection.
- (3) Check the wearing surfaces of the cartridge parts for scoring or excessive wear. Remove light score marks by lapping. Replace heavily scored or badly worn parts.

## NOTE

Cartridge kits are available assembled and pre-tested. If the old cartridges are worn extensively, kit replacement will be advantageous.

- (4) Inspect vanes (11 and 24) and inserts (10 and 23) for burrs, wear, and excessive play in rotor slots (9 and 22). Replace rotor if slots are worn.
- (5) Rotate shaft bearing (31) while applying pressure to check for wear, looseness and / or rough races. Replace as required after removing retainer ring (32).

## CAUTION

When replacing bearing, make sure that the inner race of bearing is supported in the arbor press.

- (6) Inspect seal and bushing mating surfaces on shaft for scoring or wear. Remove light scoring by lapping; otherwise, replace shaft (30).
- d. **Assembly.**

- (1) Coat all pump parts with clean hydraulic fluid to facilitate reassembly. Apply small amounts of petroleum jelly to all preformed packing to hold in place during assembly.
- (2) Place the rotor (22) on the pressure plate (39) with the arrows on the rotor pointed in the correct direction of rotation.

## NOTE

The correct direction of rotation is left hand (counterclockwise) when viewed from the shaft end of the pump).

- (3) Insert the vane (23 and 24) in the rotor with the radius edges of the vanes facing towards the ring (21) when installed.
- (4) Install the two locating pins (14) in the pressure plate (39).
- (5) Place the ring (21) on the pressure plate (39) with the ring arrow pointing in the correct direction of rotation.
- (6) Apply a small amount of good grade of sealant to the threads of screws (18). Install the

wear plates (20) on the ring (21). Insert the screws in the wear plate. Engage in pressure plate and tighten securely.

(7) Install new shaft wiper (26) and seal (27) in body (25). Use seal installing tool (fig. 2-1) to avoid damaging seal.

(8) Clamp body (25) in a vise and install washer (28) against seal.

(9) Press shaft (30) into bearing (31) in an arbor press, supporting inner bearing race. Install retainer ring (32).

(10) Tape end of shaft and lubricate seal lip with grease or petroleum jelly.

(11) Tap shaft and bearing into body and install lockring (33).

(12) Install preformed packing (35) on pressure plate hub (39). Install back-up ring (34).

(13) Install packing (36) and back-up ring (37) on pressure plate hub (39). Lay the body packing (38) in place and install the cartridge assembly in the body so that one of the flats on ring (21) will align with the inlet port when the inlet housing (17) is installed.

(14) Place the inlet housing (17) over the cartridge so that the locating pins are properly engaged, and the inlet is in the correct position with respect to the body outlet.

(15) Install the four bolts (16) and tighten to a torque of 85-95 pound-feet.

(16) Assemble the cover end cartridge by placing the rotor (9) on the pressure plate (8) with the arrow on the rotor pointed in the correct direction of rotation. Insert the vanes (10 and 11) in the rotor with the radius edges of the vanes facing towards the ring (12) when installed. Install the two locating pins (14) in the pressure plate (8). Place the ring (12) on the pressure plate with the ring arrow pointing in the correct direction of rotation. Apply a small amount of good grade of sealant to the threads of screws (15). Install the wear plate (13) on the ring (12). Insert the screws in the wear plate. Engage in pressure plate (8) and tighten securely.

(17) Install the cover end cartridge, making sure that the locating pins engage in the body. Place the back-up ring (6) and packing (5) on the pressure plate hub (8).

(18) Place the packing (7) in its groove in the

cover (2) and replace the cover, securing with four screws (1). Tighten to a torque of 65-75 pound-feet.

#### *e. Test.*

(1) Mount hydraulic pump on bench.

(a) Provide a 2.5 hp drive motor capable of driving pump at 1200 rpm.

(b) Provide an oil reservoir of 25 gallons.

(c) Install hose from pump inlet port to oil reservoir.

(d) Install hose from pump outlet port (on shaft end) to tester (see TM 5-3810-290-12) Inlet port.

(e) Install hose from pump outlet port (on cover end) reservoir.

(f) Install hose from tester outlet port to reservoir.

(g) Position reservoir so bottom of reservoir is level with or above pump inlet port and fill with OE-10 engine oil.

(2) Drive pump at 1200 rpm and measure gpm at 150° F (66° C).

#### NOTE

To heat oil, load to 1750 psi. Cycle load, unload every 3-4 seconds until required temperature is reached (approximately 30 minutes).

(a) Pump is rated 25 gpm at 1200 rpm and 100 psi.

(b) To compute gpm at differing rpm; multiply the rated gpm by actual rpm and divide by 1200.

#### NOTE

Ensure that air is not induced by intake line leakage or turbulence in reservoir. Air in test system will adversely affect gpm readings.

(3) Repeat test (para 2 above) on cover end of pump.

(a) Install hose from pump outlet (on cover end) to tester.

(b) Install hose from pump outlet (shaft end) to reservoir.

(c) Pump is rated 17 gpm at 1200 rpm and 100 psi.

(4) Volumetric efficiency should be 84% or greater. Compute by dividing actual gpm by rated gpm.

*f. Installation.* Refer to TM 5-3810-290-12 and install pump.

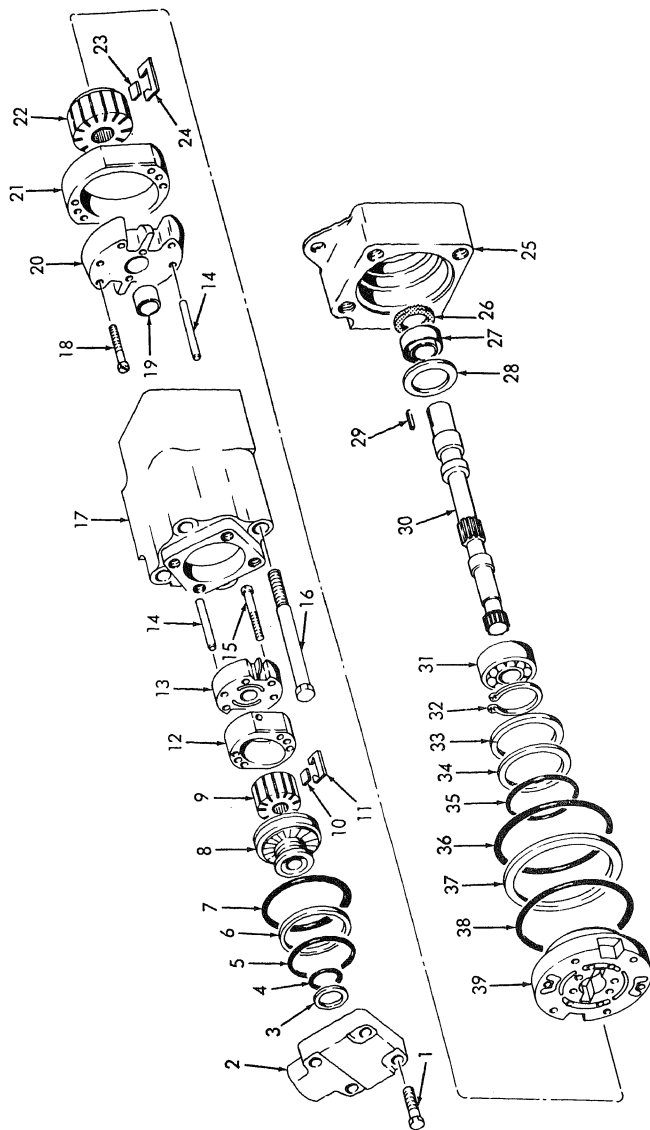


Figure 3-12. Hydraulic pump, exploded view.

Key to figure 3-12.

1. Bolt (4)
2. Outlet cover
3. Back-up ring \*
4. Preformed packing \*
5. Preformed packing \*
6. Back-up ring \*
7. Preformed packing \*
8. Pressure plate \*\*
9. Rotor \*\*
10. Insert (10) \*\*
11. Vane (10) \*\*
12. Ring \*\*
13. Wear plate \*
14. Locating pin (4) \*\*
15. Screw (2) \*\*
16. Bolt (4)
17. Inlet housing
18. Screw (2) \*\*
19. Bushing \*\*
20. Wear plate \*\*
21. Ring \*\*
22. Rotor \*\*
23. Insert (10) \*\*
24. Vane (10) \*\*
25. Body
26. Wiper
27. Seal
28. Washer
29. Key
30. Shaft
31. Bearing
32. Retainer
33. Lock ring
34. Back-up ring \*
35. Preformed packing \*
36. Preformed packing \*
37. Back-up ring \*
38. Preformed packing \*
39. Pressure plate \*\*

\* Included in seal kit.

\*\* Included in cartridge kits which all include all seal kit components.

### 3-17. Reduction Gear Box

*a. Removal.* Remove the reduction gear box (refer to TM 5-3810-290-12).

*b. Disassembly.*

(1) Remove drain plug (23, fig. 3-13) and drain lubricant from gear box.

(2) Remove vent plug (4), elbow (3), plug (2), and elbows (1) from gear box.

(3) Remove seven capscrews (16) and lockwashers (15) that secure cover (14).

(4) Remove ten capscrews (19), lockwashers (20), four capscrews (17), and lockwashers (18). Remove cover (21) and discard gasket (22).

(5) Remove the input shaft assembly from gear box. Remove two screws (12) and bearing retainer (11). Pull outer bearing (9) and gear (10) from shaft (7). Remove key (8) and pull remaining bearing (9) from shaft.

(6) Remove output gear and shaft assembly with suitable puller remove bearings (24 and 27). Remove gear (25) and key (8) from hollow shaft (26).

(7) Remove seal (6) from case (5) and discard.

#### *c. Cleaning, Inspection and Repair.*

(1) Clean all parts in an approved cleaning solvent and dry thoroughly.

(2) Rotate bearing by hand to detect binding or roughness. Replace defective bearings.

(3) Inspect gears for broken or cracked teeth and signs of wear. Replace gears as required.

(4) Inspect shafts for scoring or other damage. Remove light scoring with fine crocus cloth.

(5) Inspect case (5) and cover (21) for cracks, damaged threads or other damage. Replace as required.

#### *d. Assembly.*

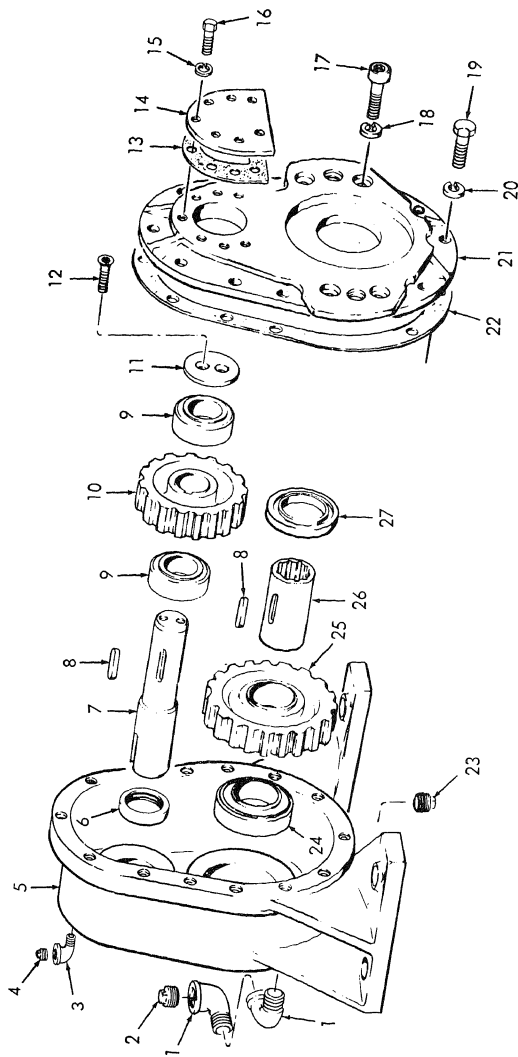
(1) Assemble the reduction gear box in the reverse order of disassembly.

(2) Install a new seal (6) and gasket (22).

(3) Check back lash of gears. Maximum allowable backlash is 0.010 inch. Replace gears if backlash exceeds this limit.

(4) Add lubricant in accordance with current lubrication order.

*e. Installation.* Refer to TM 5-3810-290-12 and install the reduction gear box.





3. Elbow
4. Vented plug
5. Case
6. Seal
7. Input shaft
8. Key (2)
9. Bearing (2)
10. Gear
11. Gear retainer
12. Screw (2)
13. Gasket

17. Capscrew (4)
18. Lockwasher (4)
19. Capscrew (10)
20. Lockwasher (10)
21. Cover
22. Gasket
23. Plug
24. Bearing
25. Gear
26. Hollow shaft
27. Bearing

## Section VI. CRANE CONTROL VALVES

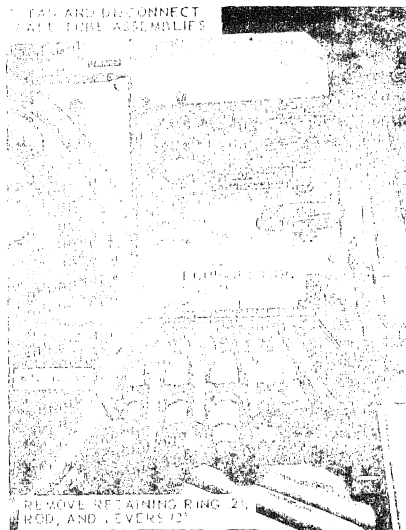
### 3-18. General

The Crane control valve banks are multi-section units, assembled to perform their specific function. A four-section unit, mounted directly in front of the operator controls the basic functioning of the hoist (fig. 3-14). A seven-section unit mounted at the left of the operator, controls the swing, outrigger, and miscellaneous functions (fig. 3-15). Relief valve pressures are set at 2000 psi.

#### 3-19. Four-Section Valve

##### a. Removal.

- (1) Remove knobs (fig. 3-14) from levers.
- (2) Remove three levers on four-section valve as instructed in figure 3-14.
- (3) Disconnect hydraulic lines connected to four-section valve bank (fig. 3-14).
- (4) Refer to paragraph 6-5 and remove right hand side door and assembly and ventilator frame from cab base.
- (5) Reach in through right hand side door assembly opening and remove capscrews, lockwashers and nuts securing four-sections valve to bracket, and remove valve.



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Figure 3-14. Four-section valve, removal and installation.

*b. Disassembly.*

(1) Remove nuts (30, fig. 3-15) and studs (29), to separate the four valve sections. Remove spacers (18) and preformed packings (15 and 16).

**NOTE**

There are four spacers (18) between each valve sections (12 total).

(2) Remove plug (35), spring (32), and poppet valve (31) from valve sections (14, 21 and 28). Remove and discard packing (33) and back-up ring (34).

(3) Remove plugs (26 and 27).

(4) Remove plug (22), packing (23), spring (24), and control valve from valve section (28).

(5) Remove screws (20), cap (19) and gasket (12) from valve sections (17, 21 and 28).

(6) Pull spools with assembled centering springs (10) from valve sections (17, 21 and 28).

**NOTE**

Centering spring (10) and retainers (8 and 9) should not be removed unless replacement is necessary.

**CAUTION**

**Keep each spool with its respective section. They are not serviced separately and are not to be interchanged.**

(7) Remove two plugs (1), springs (2), and piston (3). Remove capscrews (36), cap (4) and preformed packing (13).

(8) Pull operating spool, with assembled, centering spring (10) and detent (11).

**NOTE**

Centering spring (10) retainers (8 and 9), detent (11), and retainer should not be removed unless replacement is required.

(9) Remove two preformed packings (13) from each spool bore.

*c. Cleaning, Inspection and Repair.*

(1) Clean all parts with an approved solvent. Dry thoroughly with filtered compressed air. Place on clean surface for inspection.

(2) Check spools carefully. Remove light scoring with lapping stone or fine crocus cloth. Otherwise, replace spool with new mating section.

(3) Remove any foreign material or burred edges from mating surfaces of valve sections.

*d. Assembly.*

(1) Coat all parts with clean hydraulic fluid. Coat all seals and packing with petroleum jelly.

(2) Assemble the sections and component parts in the reverse order of disassembly.

(3) Assemble the four sections on a surface plate or other plane surface to provide accurate alignment.

(4) Coat the stud threads with a good grade sealant. Tighten the nuts (30) to a torque of 45-50 pound-feet.

*e. Installation.*

(1) Install the valve unit. Secure loosely with attaching hardware.

(2) Connect hydraulic lines. Tighten to 35-40 pound-feet torque.

(3) Tighten mounting bolts.

(4) Install levers in reverse of removal.

(5) Apply hydraulic pressure and inspect for leaks. Correct as required.

(6) Refer to paragraph 6-5 and install right hand side door assembly and ventilator frame.

**Key to figure 3-15.**

1. Plug (2)
2. Spring (2)
3. Piston (2)
4. Cap
5. Retaining ring
6. Washer
7. Screw (4)
8. Guide (4)
9. Spring retainer (8)
10. Spring (4)
11. Detent
12. Packing retainer (4)
13. Preformed packing (8)
14. Outlet section "CL" w / spool
15. Preformed packing (12)
16. Preformed packing (3)
17. Center section "B" w / spool
18. Shim (12 \*
19. Cap (3)
20. Capscrew (6)
21. Center section "D" w / spool
22. Plug
23. Preformed packing
24. Spring
25. Control valve
26. Plug
27. Plug
28. Inlet section "R25D" w / spool
29. Stud (4)
30. Locknut (4)
31. Poppet valve (3)
32. Spring (3)
33. Preformed packing
34. Back-up ring (3)
35. Plug (3)
36. Capscrew (2)

\* 4 shims required between each valve section.

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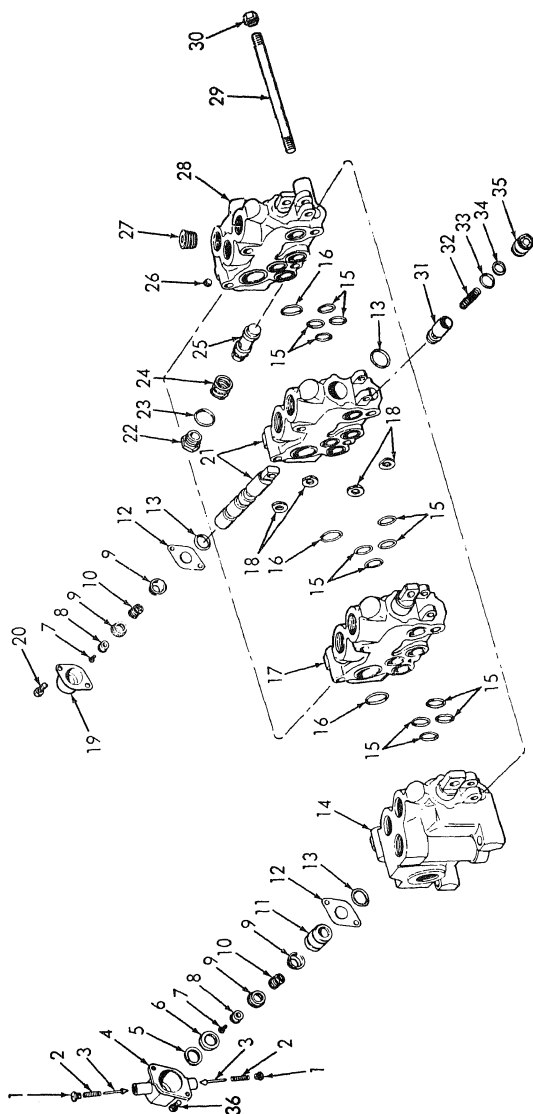
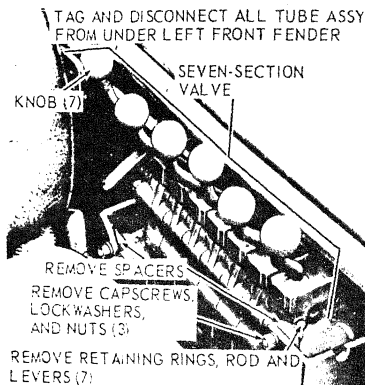


Figure 3-15. Four-section valve assembly, exploded view.

### 3-20. Seven-Section Valve

#### a. Removal.

- (1) Remove knobs (fig. 3-16) from levers.
- (2) Remove seven levers on seven-section valve as instructed in figure 3-16.
- (3) Disconnect hydraulic lines connected to seven-section valve bank (fig. 3-16).
- (4) Remove capscrews, lockwashers, and nuts (fig. 3-16) securing seven-section valve to bracket, and remove valve.



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Figure 3-16. Seven-section valve, removal and installation.

#### b. Disassembly.

- (1) Remove the nuts (12, fig. 3-17) and studs (13).
- (2) Separate the sections.
  - (a) Inlet section (11).
  - (b) Center sections (6).
  - (c) Outlet section (11).

#### CAUTION

Mark sections so they may be assembled in their same respective positions, upon reassembly.

- (3) Remove the screws (26), retainer (25), and sleeve (24).
- (4) Slide the spool (21) out of the section and remove the preformed packing (23 and 27). Do not remove the centering spring (22) and "C" washers (28) unless it is necessary to replace them.

#### CAUTION

Keep each spool with its respective section. They are not serviced

separately and are not to be interchanged.

- (5) Remove the check valve plug (17) from the outlet section (11). Remove the packing (18) back-up ring (16), spring (15) and ball (14).

- (6) Remove the plug (5), packing (4), spring (3), and valve (2) from the inlet section (11).

- (7) Remove the retainer (8) and packing (7)

#### NOTE

During disassembly of valve assembly, seals (9, 19 and 20) and retainer (10) should be removed. Discard all seals and preformed packing removed. Replace with new seals and packing contained in seal kit when assembling valve assembly.

#### c. Cleaning, Inspection, and Repair.

- (1) Clean all parts with an approved solvent. Dry thoroughly with filtered compressed air. Place on clean surface for inspection.

- (2) Check spools carefully. Remove light scoring with lapping stone or fine crocus cloth. Otherwise, replace spool with new mating section.

- (3) Remove any foreign material or burred edges from mating surfaces of valve sections.

#### d. Assembly.

- (1) Coat all parts with clean hydraulic fluid. Coat all seals and packing with petroleum jelly.

- (2) Assemble sections and component parts in the reverse order of disassembly.

- (3) Assemble the sections on a surface plate or other plane surface to provide accurate alignment.

- (4) Coat the stud threads with a good grade of sealant. Tighten the nuts to a torque of 15 pound-feet.

#### e. Installation.

- (1) Install the valve unit. Secure loosely with attaching hardware.

- (2) Connect hydraulic lines. Tighten to 35-40 pound-feet torque.

- (3) Tighten mounting bolts.

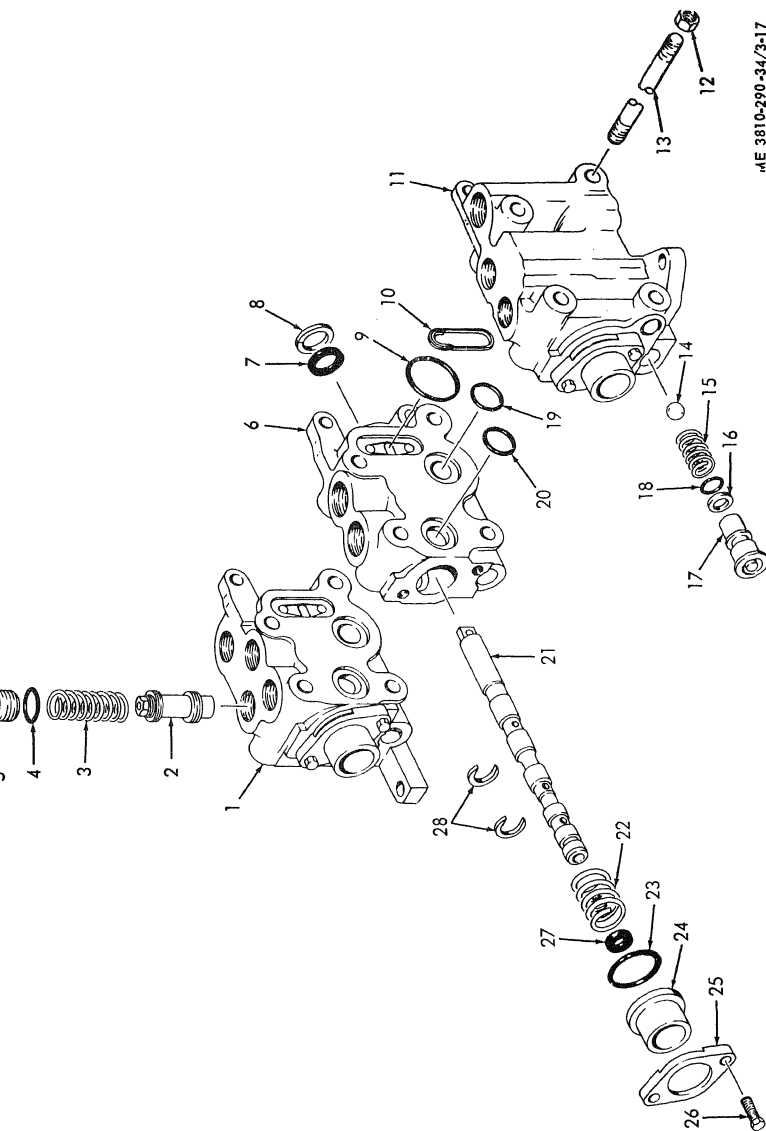
- (4) Install levers in reverse of removal.

- (5) Apply hydraulic pressure and inspect for leaks. Correct as required.

#### Key to figure 3-17.

- |                              |                              |
|------------------------------|------------------------------|
| 1. Inlet section             | 15. Spring                   |
| 2. Valve                     | 16. Back-up rings *          |
| 3. Spring                    | 17. Plug                     |
| 4. Preformed packing *       | 18. Preformed packing *      |
| 5. Plug                      | 19. Seal *                   |
| 6. Center section (see text) | 20. Seal *                   |
| 7. Preformed packing *       | 21. Spool                    |
| 8. Back-up ring *            | 22. Centering spring         |
| 9. Seal *                    | 23. Preformed packing *      |
| 10. Back-up ring *           | 24. Sleeve                   |
| 11. Outlet section           | 25. Retainer                 |
| 12. Nut (4)                  | 26. Screw (2)                |
| 13. Stud (4)                 | 27. Preformed packing *      |
| 14. Ball                     | 28. "C" Washer (2 per spool) |

\* Included in seal kit.



TM 5-3810-290-34/3-17

Figure 3-17. Seven-section valve assembly, exploded view.

## Section VII. CRANE STABILIZERS

## 3-21. General

Two methods of stabilizing the crane are employed. The first method utilizes two hydraulic cylinders which lock the carrier frame to the rear axle and assures maximum rigidity between the crane and carrier. The second method employs four outrigger arms, hydraulically actuated, for utilization in stabilizing the crane and carrier when lifting heavy loads with extended boom; or operating on sloping terrain and under adverse conditions.

## 3-22. Hydraulic Stabilizing Cylinder

a. *Removal.* Remove the stabilizing cylinder. (Refer to TM 5-3810-290-12).

b. *Disassembly.*

(1) Unscrew the head (6, fig. 3-18) from the body (2). Remove and discard the packing (5 and 7) and wiper (8).

(2) Withdraw the piston and rod (4).

(3) Remove and discard the packing (3).

c. *Cleaning, Inspection, and Repair.*

(1) Clean all parts with an approved cleaning solvent. Dry thoroughly.

(2) Inspect the bore of the cylinder (2) and the piston rod (4) for scoring. Remove fine scoring marks with a lapping stone or fine crocus cloth. Replace deeply scored parts.

d. *Assembly.*

(1) Install new preformed packing (3) on piston (4).

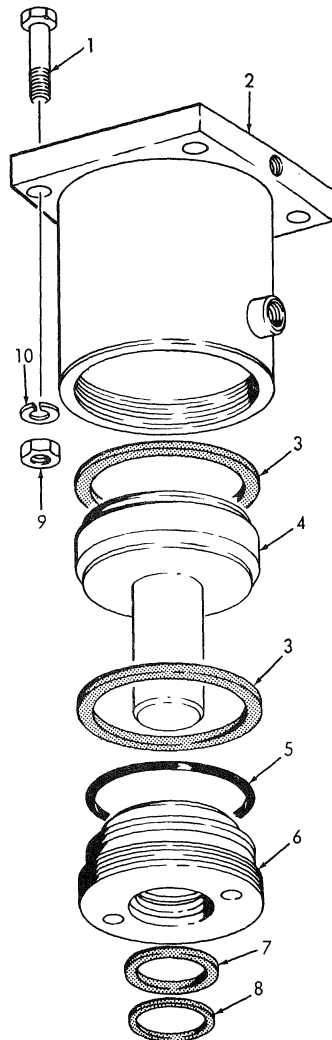
(2) Lubricate all surfaces lightly with clean hydraulic fluid.

(3) Replace piston and rod (4) in body (2).

(4) Install new preformed packing (5 and 7) and wiper (8) in head (6).

(5) Install head in body (2) and tighten securely.

e. *Installation.* Refer to TM 5-3810-290-12 and install the cylinder on the crane in the reverse order of removal.



Key to figure 3-18.

1. Capscrew (4)
2. Body
3. Preformed packing (2)
4. Piston and rod
5. Preformed packing
6. Head
7. Preformed packing
8. Wiper
9. Nut (4)
10. Lockwasher (4)

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### 3-23. Outtrigger Arms

There are four outtrigger arms, each hydraulically and independently controlled to stabilize the crane platform under a relatively wide area of operation deviating from a true horizontal position.

*a. Removal and disassembly.* Refer to TM 5-3810-290-12 and remove and disassemble the outtrigger arms.

#### *b. Repair.*

- (1) Replace defective parts.
- (2) Replace pad if extremely wobbly.
- (3) Replace micro-switch if defective.
- (4) Weld arms if it has cracks or broken arms.

*c. Assembly and installation.* Refer to TM 5-3810-290-12 and assemble and install outtrigger arms.

### 3-24. Outtrigger Arm Cylinder

*a. Removal.* Remove the outtrigger cylinder. (Refer to TM 5-3810-290-12).

#### *b. Disassembly.*

(1) Remove tube assembly (13, fig. 3-19), connector (14), elbow (12), reducer (11), and pilot piston (8). Remove and discard packing (9 and 10).

(2) Remove four capscrews (25), and remove assembled rod, piston, and head from body (15).

(3) Remove locknut (16), piston (17), packing (31), piston sleeve (33), packing (32) and piston follower (30) from rod end. Slide rod (21) from head assembly.

(4) Remove capscrews (22), gland (24), wiper (23), packings (26 and 29), and bushing (27) from head (28).

(5) Remove plug (34), spring (35), and ball (36) from body (15). Discard packing (10).

#### *c. Cleaning, Inspection, and Repair.*

(1) Clean all parts with an approved cleaning solvent. Dry thoroughly.

(2) Inspect the body, rod, and piston for scoring. Remove fine scoring with a lapping stone or fine crocus cloth. Replace scored parts.

#### *d. Assembly.*

(1) Reassemble the piston rod assembly components in the reverse order of disassembly.

(2) Replace all packing and seals with new parts.

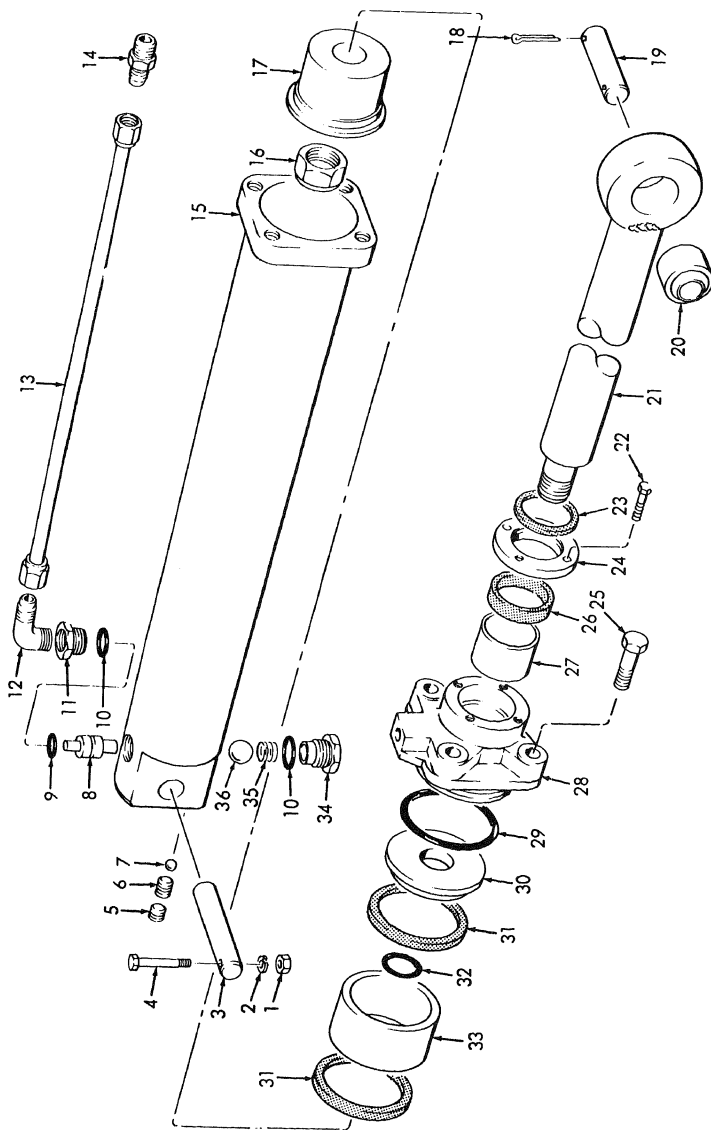
(3) Lubricate the piston rod assembly lightly with clean hydraulic fluid.

(4) Install the piston rod assembly in the body. Tighten the head (28) securely.

*e. Installation.* Refer to TM 5-3810-290-12 and install the outtrigger arm cylinder in reverse of removal.

#### Key to figure 3-19.

1. Nut
2. Lockwasher
3. Pin
4. Capscrew
5. Screw
6. Plug
7. Ball
8. Pilot piston
9. Packing
10. Packing
11. Reducer
12. Elbow
13. Tube assembly
14. Connector
15. Body
16. Locknut
17. Piston
18. Cotter pin
19. Pin
20. Bearing
21. Rod
22. Capscrew
23. Rod wiper
24. Gland
25. Capscrew
26. Packing
27. Bushing
28. Head
29. Packing
30. Piston follower
31. Packing
32. Packing
33. Piston sleeve
34. Plug
35. Spring
36. Ball



ME 3810-290-34/3+19



## REPAIR OF ENGINE AND COMPONENTS

### Section I. GENERAL

#### 4-1. General

a. The 6V-53 engine is a 6-cylinder, wet-cylinder liner, fuel injected, 2-cycle, V-type diesel engine. The cylinders are numbered one, two, three, right and left from the front, or fan end, of the engine. The terms "right", "left", "front", and "rear" used in referring to the engine and its components, are as

viewed from the rear of flywheel end of the engine. Engine rotation is clockwise, as viewed from the front of fan end of the engine, as shown in figure 4-1. Cylinder firing order of the engine is as follows: 1 left, 3 right, 3 left, 2 right, 2 left, and 1 right as shown in figure 4-1.

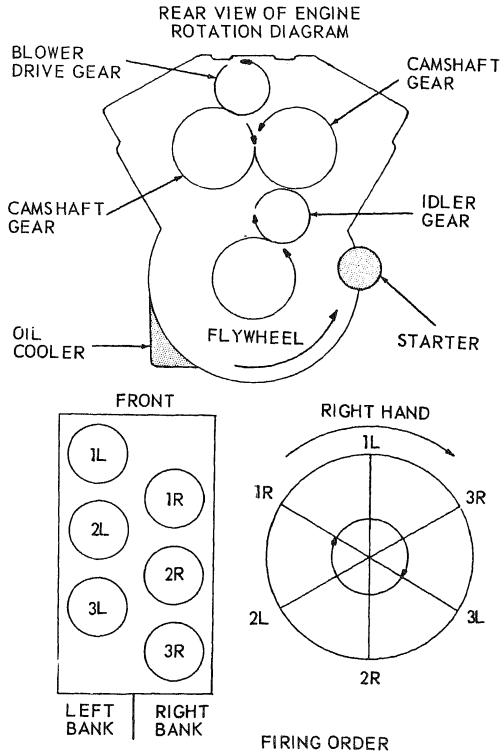
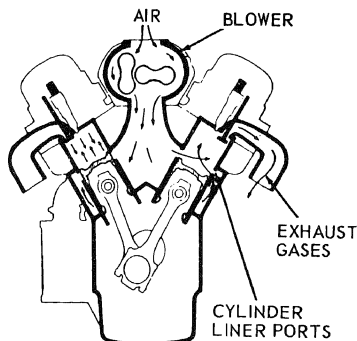
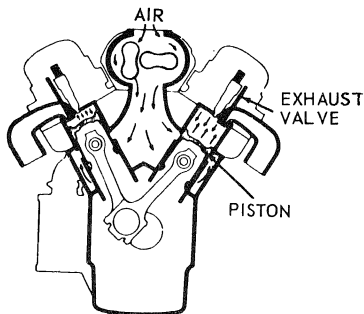


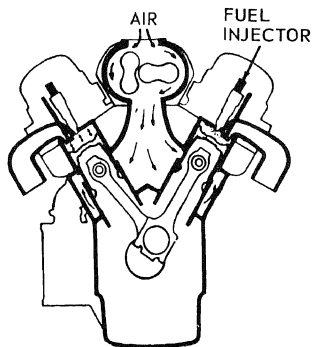
Figure 4-1. Engine rotation diagram and firing order.



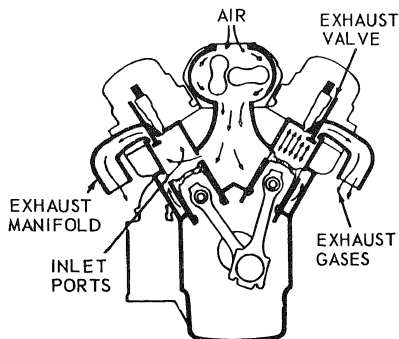
A. SCAVENGING DIAGRAM.



B. COMPRESSION DIAGRAM.



C. POWER DIAGRAM.



D. EXHAUST DIAGRAM.

ME 3810-290-34/4-2

Figure 4-2. Two cycle sequence.

b. The following and subsequent paragraphs of repair instructions are presented from the standpoint of having the engine assembly removed from the carrier as instructed in paragraph 2-8, and mounted on a suitable work stand. Some of the engine accessories and sub-assemblies may, however, be removed (Sec. III. Chap. 2) with the

engine assembly still installed in the carrier. The accessories and sub-assemblies are so indicated their respective, general sub-paragraphs.

c. Table 4-1. Repair and Replacement Standards, lists manufacturer's sizes, tolerances, desired clearances, and maximum allowable wear at clearances.

Table 4-1. Repair and Replacement Standards

| Component                                | Manufacturers dimensions and tolerances in inches |         | Maximum allowable wear and clearance |
|--|---|---------|--------------------------------------|
|  | Minimum   | Maximum |                                      |
| ENGINE                                   |   |         |                                      |
| Cylinder Block                           |   |         |                                      |
| Cylinder bore                            |   |         |                                      |
| Diameter (A. fig 4-53)                   |   | 4.5235  |                                      |
| (B. fig. 4-53)                           |   | 4.4900  |                                      |
| (C & D. Fig 4-53)                        |   | 4.3595  |                                      |
| Out-of-round                             |   |         | 0.0015                               |
| Taper                                    |   |         | 0.0015                               |
| Cylinder liner counterbore               |   |         |                                      |
| Diameter                                 | 4.8200  | 4.8350  |                                      |
| Depth                                    | 0.3000  | 0.3020  |                                      |
| Main bearing bores                       |   |         |                                      |
| Inside diameter                          | 3.751   | 3.752   |                                      |
| Top surface of cylinder block            |   |         |                                      |
| Flatness-transverse                      |   |         | 0.003                                |
| Flatness-longitudinally                  |   |         | 0.006                                |
| Cylinder liners                          |   |         |                                      |
| Seal ring surface                        |   |         |                                      |
| Outside diameter                         | 4.4850  | 4.4860  |                                      |
| Inside diameter                          | 3.8752  | 3.8767  |                                      |
| Out-of-round                             |   | 0.0020  | 0.003                                |
| Taper                                    |   | 0.0010  | 0.002                                |
| Cylinder Head                            |   |         |                                      |
| Flatness-transverse                      |   |         | 0.004                                |
| Flatness-longitudinally                  |   |         | 0.005                                |
| Valve insert counterbores                |   |         |                                      |
| Diameter                                 | 1.1590  | 1.1600  |                                      |
| Depth                                    | 0.298   | 0.302   |                                      |
| Water nozzles to surface of head         | 1 / 32  | Flush   |                                      |
|  | Recess  |         |                                      |
| Exhaust Valve Seat Inserts               |   |         |                                      |
| Face angle —30°                          |   |         |                                      |
| Seat width                               | 3 / 64  | 5 / 64  |                                      |
| Exhaust Valves                           |   |         |                                      |
| Stem diameter                            | 0.2480  | 0.2488  |                                      |
| Valve head to cylinder head              | Flush   | 0.0240  | 0.390                                |
| Valve Guides                             |   |         |                                      |
| Distance below top of head               | 0.1900  | 0.2200  |                                      |
| Diameter-inside                          | 0.2505  | 0.2515  |                                      |
| Clearance-stem to guide                  | 0.0017  | 0.0035  | 0.0050                               |
| Rocker Arms and Shafts                   |   |         |                                      |
| Rocker shaft diameter                    | 0.8735  | 0.8740  |                                      |
| Rocker arm shaft bushing inside diameter | 0.8750  | 0.8760  |                                      |
| Clearance—shaft to bushing               | 0.0010  | 0.0025  | 0.0040                               |
| Cam Followers                            |   |         |                                      |
| Diameter                                 | 1.0600  | 1.0610  |                                      |
| Clearance-follower to head               | 0.0016  | 0.0036  | 0.0060                               |
| Cam Follower Rollers and Pins            |   |         |                                      |
| Clearance-Pin to bushing                 | 0.0013  | 0.0021  | 0.0100<br>(horiz)                    |
|  |   |         | 0.0230                               |
| Side clearance-roller in follower        | 0.0150  | 0.0230  |                                      |
| Roller outside diameter                  | 0.9020  | 0.9070  |                                      |
| Roller bushing inside diameter           | 0.4390  | 0.4395  |                                      |
| Roller pin outside diameter              | 0.4374  | 0.4377  |                                      |
| * Crankshaft                             |   |         |                                      |
| Journal diameter-main bearing            | 3.4990  | 3.5000  |                                      |
| Journal diameter-conn. rod               | 2.7490  | 2.7500  |                                      |
| Journal out-of-round                     |   | 0.00025 |                                      |
| Journal taper                            |   | 0.0005  | 0.0030                               |
| Hub outside diameter                     | 2.1825  | 2.1835  |                                      |

Table 4-1. Repair and Replacement Standards—Continued

| Component   | Manufacturers dimensions and tolerances in inches |          | Maximum allowable wear and clearance |
|---|---|----------|--------------------------------------|
|   | Minimum   | Maximum  |                                      |
| <i>Crankshaft—Continued</i>                                   |   |          |                                      |
| Clearance-bearing to hnb                                      | 0.0025  | 0.0045   | 0.007                                |
| Thrust washer thickness                                       | 0.118   | 0.120    |                                      |
| End play  | 0.006   | 0.013    | 0.017                                |
| <i>Crankshaft Timing Gear</i>                                 |   |          |                                      |
| Backlash  | 0.003   | 0.005    | 0.007                                |
| <i>Blower Drive Gear</i>                                      |   |          |                                      |
| Backlash  | 0.003   | 0.005    | 0.007                                |
| Shaft end play  | 0.004   | 0.006    |                                      |
| Thrust washer thickness                                       | 0.093   | 0.103    |                                      |
| <i>Governor Drive Gear</i>                                    |   |          |                                      |
| Backlash  | 0.003   | 0.005    | 0.007                                |
| Runout at journals-total indicator reading                    |   | 0.0020 * |                                      |
| (mounted on No. 1 & No. 4 journals at No. 2 & No. 3 journals) | 0.1205  | 0.1220   |                                      |
| Thrust washer thickness                                       | 0.0040  | 0.0110   | 0.0180                               |
| End thrust clearance (end play)                               |   |          |                                      |
| Tolerance given for guidance when regrinding crankshaft       |   |          |                                      |
| <i>Main Bearings</i>  |   |          |                                      |
| Bearing inside dia. (vert. axis)                              | 3.5030  | 3.5040   |                                      |
| Bearing thickness —90° from parting line                      | 0.1240  | 0.1245   | 0.1230                               |
| Clearance-bearing to journal                                  | 0.0025  | 0.0057   | 0.0070                               |
| <i>Connecting Rods</i>  |   |          |                                      |
| Length-center to center                                       | 8.7900  | 8.8010   |                                      |
| Lower bore diameter   | 3.0015  | 3.0025   |                                      |
| Upper bore diameter   | 1.6000  | 1.6010   |                                      |
| Bushing inside diameter                                       | 1.3760  | 1.3765   |                                      |
| <i>Connecting Rod Bearings</i>                                |   |          |                                      |
| Inside diameter (vert. axis)                                  | 2.7511  | 2.7531   |                                      |
| Bearing thickness —90° from parting line                      | 0.1247  | 0.1252   | 0.1230                               |
| Clearance-bearing to crankshaft journal                       | 0.0016  | 0.0046   | 0.0060                               |
| <i>Piston</i>   |   |          |                                      |
| Diameter at skirt   | 3.8693  | 3.8715   |                                      |
| Clearance-piston to liner                                     | 0.0037  | 0.0074   | 0.010                                |
| Out-of-round  |   | 0.0005   |                                      |
| Taper   |   | 0.0005   |                                      |
| Piston pin bushing inside dia.                                | 1.3775  | 1.3780   |                                      |
| <i>Piston Pins</i>  |   |          |                                      |
| Diameter  | 1.3746  | 1.3750   |                                      |
| Clearance-pin to piston bushing                               | 0.0025  | 0.0034   | 0.010                                |
| Clearance-pin to rod bushing                                  | 0.0010  | 0.0019   | 0.010                                |
| <i>Piston Rings</i>   |   |          |                                      |
| Compression rings—  |   |          |                                      |
| Gap   | 0.0200  | 0.0460   | 0.060                                |
| Clearance-ring to groove                                      |   |          |                                      |
| Top (No. 1) Tapered face                                      | 0.0030  | 0.0060   | 0.016                                |
| No. 2   | 0.0070  | 0.0100   | 0.014                                |
| No. 3 and 4   | 0.0050  | 0.0080   | 0.013                                |
| Oil rings   |   |          |                                      |
| Gap   | 0.0100  | 0.0250   | 0.044                                |
| Clearance-ring to groove                                      | 0.0015  | 0.0055   | 0.008                                |
| <i>Camshaft</i>   |   |          |                                      |
| Shaft diameter at bearing                                     | 2.1820  | 2.1825   |                                      |
| Runout at center bearing (When mounted on end bearing)        |   | 0.002    |                                      |
| Thrust washer thickness                                       | 0.208   | 0.210    |                                      |
| End thrust  | 0.008   | 0.015    | 0.019                                |
| <i>Balance Shaft</i>  |   |          |                                      |
| Shaft diameter at bearings                                    | 2.1820  | 2.1825   |                                      |
| Thrust washer thickness                                       | 0.208   | 0.210    |                                      |
| End thrust  | 0.008   | 0.015    | 0.019                                |

|  | Manufacturers<br>dimensions and<br>tolerances in inches |         | Maximum<br>allowable<br>wear and<br>clearance |
|--|---|---------|---|
|  | Minimum   | Maximum |   |
| <i>Camshaft and Balance Shaft Bearings</i> |   |         |   |
| Bearing inside diameter                    | 2.187   | 2.188   |   |
| Clearance-bearing to shaft                 | 0.0045  | 0.006   | 0.008   |
| <i>Camshaft and Balance Shaft Gears</i>    |   |         |   |
| Backlash                                   | 0.003   | 0.005   | 0.007   |
| <i>Idler Gear</i>                          |   |         |   |
| Backlash                                   | 0.003   | 0.005   | 0.007   |
| Bearing inside diameter                    | 2.186   | 2.187   |   |

## GENERAL

## NOTE

Recommended maximum allowable wear and clearances specified below are generally applicable to other major components of the crane unless exception is noted in the text dealing with the respective assembly.

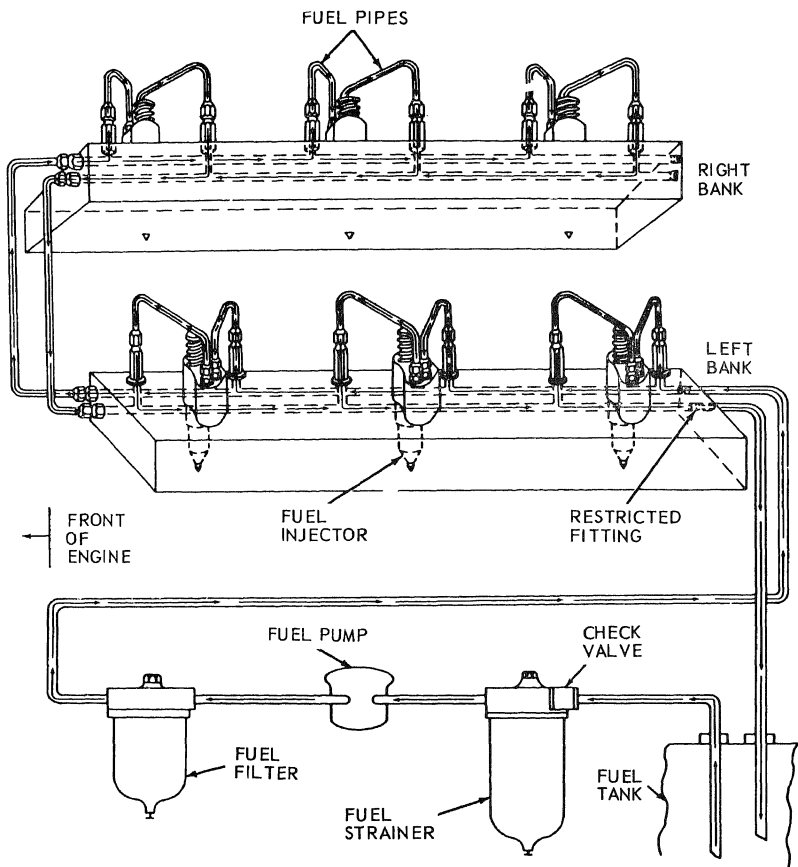
|                               |        |
|-------------------------------|--------|
| <i>Total Radial Clearance</i> |        |
| Bearings                      | 0.0025 |
| Bushings                      | 0.0035 |
| End play-shafts               | 0.0250 |

\* Tolerances given for guidance when regrinding crankshaft.

## 4-2. Engine Systems

a. *Fuel System.* The fuel system (fig. 4-3) consists of a fuel pump, strainer, filter, injectors, and related fuel lines. A restricted fitting is located in the cylinder head fuel return outlet to maintain pressure within the fuel system. The fuel pump draws fuel from the tanks through the strainer, and forces it under pressure through the filter. From the filter, the fuel is forced through the fuel inlet

passage in the cylinder head and fuel lines to the injectors. The fuel passes through a filter element within the injector to a chamber where it is metered, displaced, and atomized through the fuel injector spray tip into the combustion chamber. Excess fuel not required for engine operation is circulated through the injectors and fuel return lines as a coolant, and returned to the fuel tank.



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Figure 4-3. Fuel system.

*b. Lubrication System.* The lubrication system (fig. 4-4) consists of an oil intake screen and tube assembly, oil pump, pressure regulator, oil filter, by-pass valve, and oil cooler. The rotor-type oil pump is bolted to the back of the engine lower front cover and is driven directly by the crankshaft. Lubricating oil from the pump passes from the lower front cover through short gallery passages in the cylinder block to the oil filter adapter plate. From the adapter plate, the oil flows through the oil

filter, then through the oil cooler, and back into the front engine cover and cylinder block oil galleries from distribution to the various engine bearings. The drain from the cylinder head and other engine parts leads back to the oil pan. Clean engine oil is assured by the use of a replaceable element type filter. Should the filter become plugged, the oil will flow through a by-pass valve in the adapter plate directly to the oil cooler. If the oil cooler becomes clogged, the oil will flow directly through a by-pass

to the main crank cover to the cylinder block galleries. Stabilized oil pressure is maintained at all engine speeds by means of a regulator valve located in the lower front cover.

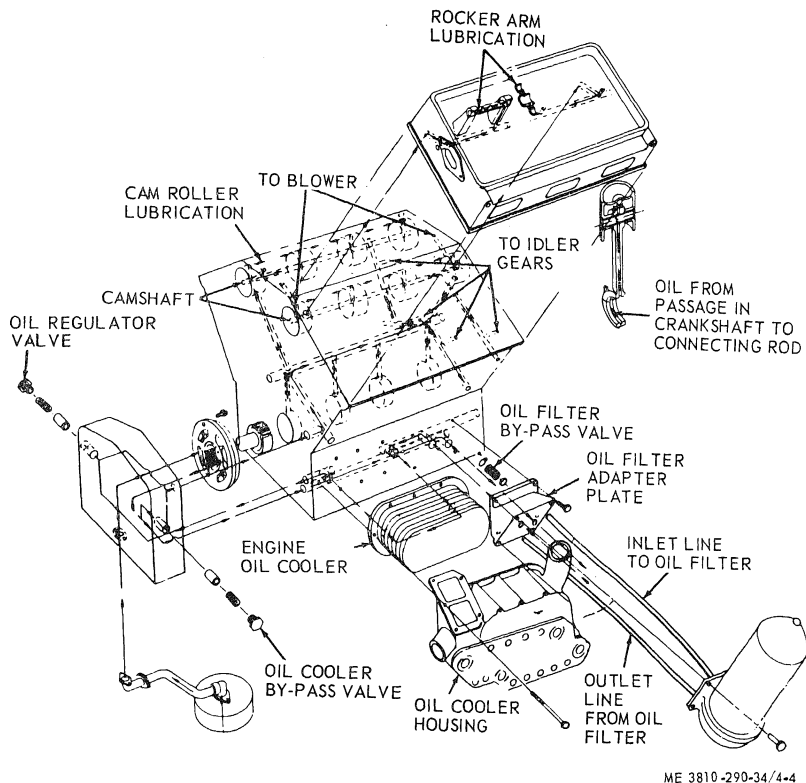


Figure 4-4. Lubrication system.

#### c. Cooling System.

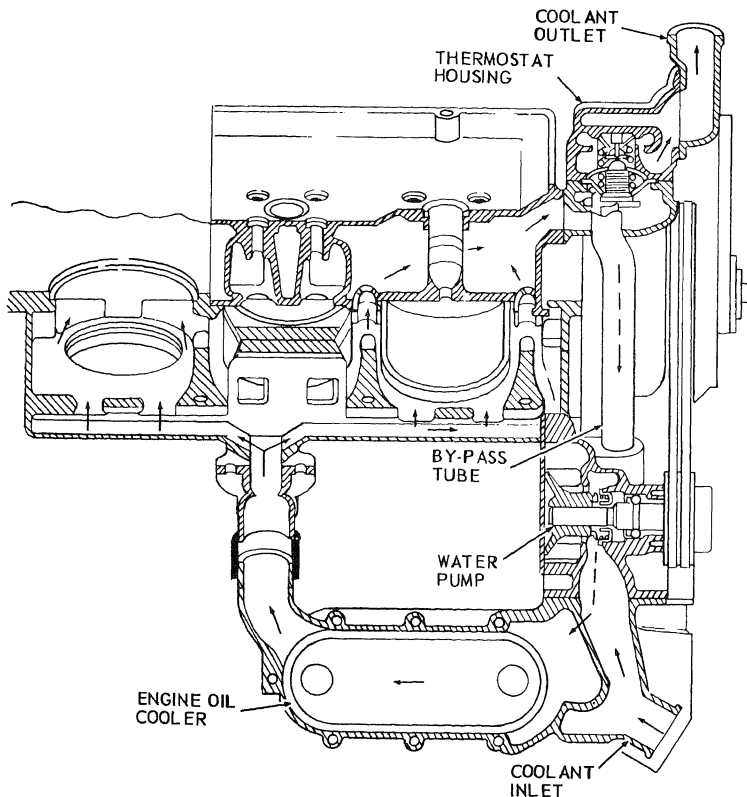
(1) The engine cooling system (fig. 4-5) includes a water pump, oil cooler water jacket, thermostat housing, water manifold, by-pass line, and cylinder block water jacket. A radiator and fan are used in the cooling system of the crane.

(2) The coolant is drawn from the radiator by the water pump and circulated through the oil cooler, cylinder block, and cylinder heads to the thermostat housing. During the warm-up period, when the coolant temperature is below normal, the thermostat blocks the flow of coolant to the radiator. During this period, the pump circulates

the coolant through the by-pass system to the cylinder block and heads. As the coolant rises above normal, the thermostat opens and the coolant is circulated through the radiator.

d. Crankcase Ventilation System. The crankcase ventilation system consists of a breather tube assembly, collector, and crankcase vapor passages. Vapors formed within the engine are removed from the crankcase, gear train, and valve compartment by a continuous, automatic ventilation system. A slight pressure is maintained in the engine crankcase by the seepage of a small amount of air from

the air box past the piston rings. This air sweeps up through the engine and is drawn off through the breather tube and collector.



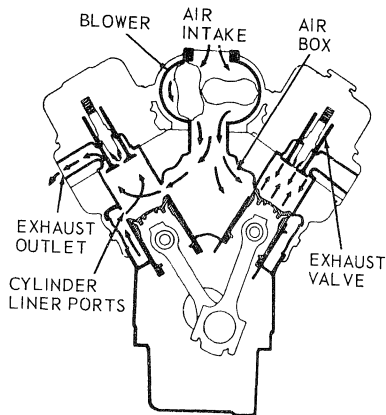
ME 3810-290-34/4-5

Figure 4-5. Cooling system.

*e. Air Induction System.* The air induction system (fig. 4-6) consists of an air cleaner, blower, cylinder block air chamber, cylinder line intake ports, and exhaust valve ports. In the scavenging process employed in the 6V-53 diesel engine, a charge of air is forced into the cylinders by the blower and thorough cleaning of the

gases through the exhaust valve ports. This air helps to cool the external engine parts, particularly the exhaust valves. At the beginning of the compression stroke, each cylinder is filled with fresh clean air which provides for efficient combustion. For description, data, and service operation





ME 3810-290-34/4-6

Figure 4-6. Air induction system.

## Section II. RADIATOR ASSEMBLY

### 4-3. General

The radiator assembly consists of a top tank, radiator core, and bottom tank. The bottom tank has a separate cooling coil, which is used for cooling of the transmission fluid. The radiator assembly is connected to the thermostat housings engine oil cooler by hoses and clamps and is supported by brackets bolted to the carrier main frame (fig. 4-7).

### 4-4. Radiator Assembly

*a. Removal.* Remove the radiator assembly (Refer to TM 5-3810-290-12).

#### *b. Disassembly.*

(1) Remove screw (15, fig. 4-7), retainer clips (14) and hose (13) from radiator top tank assembly (8).

(2) Remove radiator cap (9) and preformed packing (10).

(3) Remove capscrews (11), lockwashers (12), nuts (16), and remove top tank assembly and gasket (22).

(4) Remove bolts (30), lockwashers (12), and nuts (16), and remove bottom tank assembly (23) and gasket (22).

(5) Remove pipe elbow (25) from bottom tank.

#### *c. Cleaning, Inspection, and Repair.*

(1) Flush the radiator core passages with an approved radiator cleaning solvent.

(2) Inspect the core for bent fins, straighten where possible.

(3) Plug all tube and hose connecting points of radiator except one. At the opening attach an air supply of 10 p.s.i.

#### **CAUTION**

**Do not use an air pressure greater than 10 p.s.i. as it may damage the radiator core.**

(4) Immerse the radiator in a vat of water and watch for air bubbles. Should they appear, mark the point of origin.

(5) Dry the radiator thoroughly, and if possible solder all leaks carefully. Use a minimum amount of solder and do not permit solder to leak into the radiator core.

(6) Repaint the radiator core. A thin coat of dull black radiator paint is desirable. Ordinary oil paints with glossy finishes do not transmit heat as well.

(7) Replace a top tank, bottom tank or core assembly that is damaged beyond repair.

NOTE

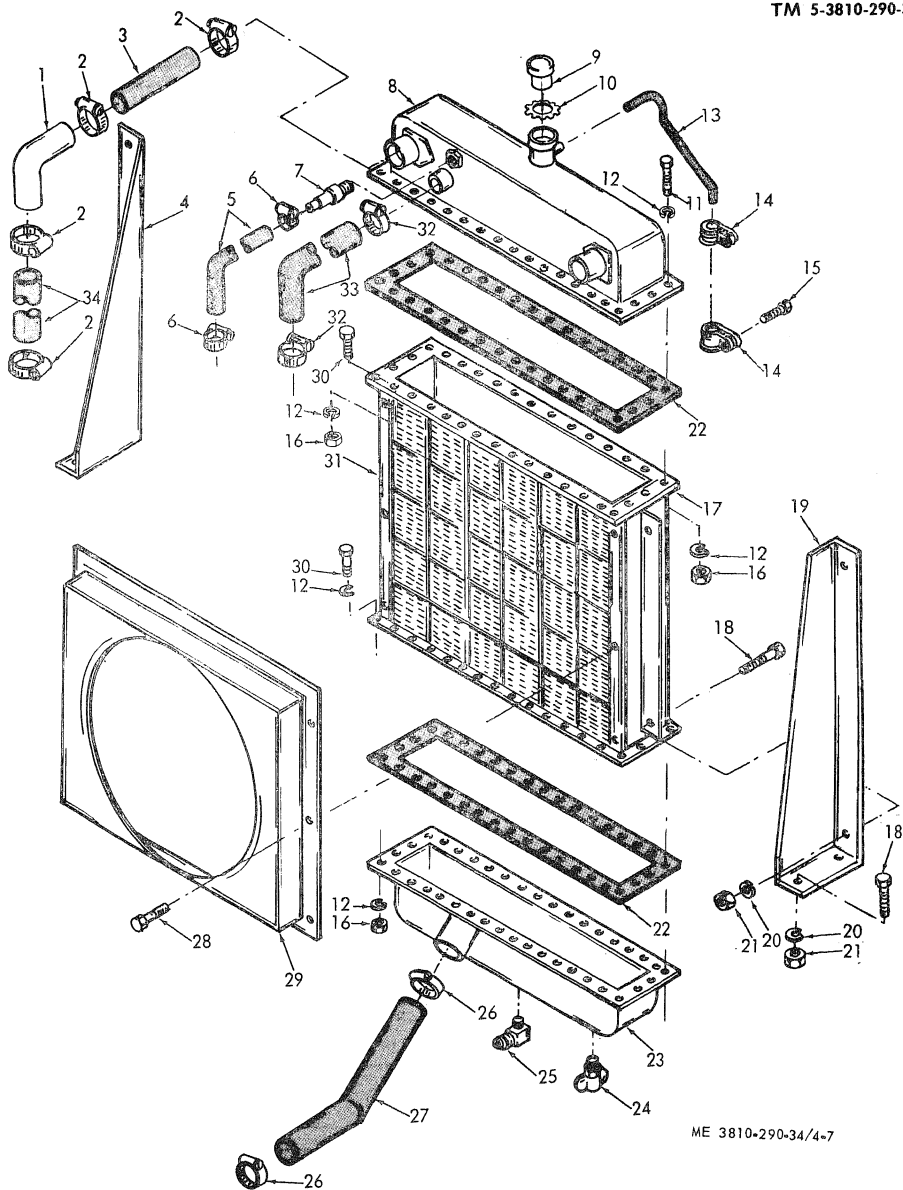
No blocked core tubes are allowed.

*d. Assembly.* Assemble the radiator in reverse order of disassembly.

*e. Installation.* Refer to TM 5-3810-290-12 and install the radiator assembly on the carrier.

Key to figure 4-7.

1. Elbow (2), water
2. Clamp (8), hose
3. Hose (2), rubber
4. L. H. Support
5. Hose, rubber
6. Clamp (2), hose
7. Adapter, hose
8. Tank assembly, top
9. Cap, radiator
10. Packing, preformed
11. Screw, cap (19), hx. hd
12. Lockwasher (72)
13. Hose, rubber
14. Clip, retainer (2)
15. Screw, machine (2)
16. Nut, plain, hexagon (53)
17. Side assembly, LH
18. Screw, cap, hex hd (8)
19. Bracket: Radiator mtg R
20. Lockwasher (8)
21. Nut, plain, hex (8)
22. Gasket, tank (2)
23. Tank assembly, bottom
24. Draincock
25. Elbow, pipe (2)
26. Clamp, hose (2)
27. Hose, rubber
28. Screw, cap (6)
29. Shroud, radiator
30. Bolt, machine (53)
31. Side assembly, RH
32. Clamp, hose (2)
33. Hose, rubber
34. Hose, rubber



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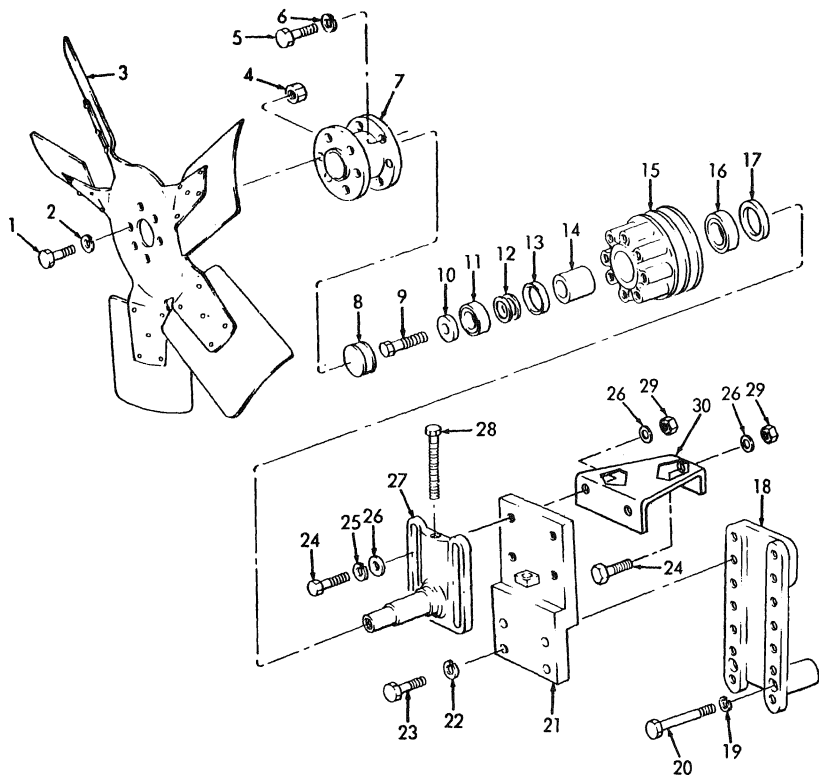
Figure 4-7. Radiator assembly and shroud, exploded view.

### Section III. FAN ASSEMBLY

#### 4-5. General

a. The engine cooling fan is driven by a pair of V-drive belts from the crankshaft pulley. The fan is

bolted to a hub extension, which in turn, is bolted to a combination fan hub and pulley which turns on two tapered roller bearings.



ME 3810-290-34/4-8

b. The tapered roller bearings, used in the fan hub, are pressure lubricated prior to assembly and the cavity between the bearings is packed approximately  $\frac{1}{4}$  full of grease at the time the hub is assembled. Also, the fan hub cap is packed approximately  $\frac{3}{4}$  full of grease. No further lubrication is required until the fan hub assembly is overhauled. The hub cap at the front and a seal at the rear of the hub prevents leakage of the lubricant.

c. The fan assembly may be removed, (para 4-6 a) without removal of the engine assembly. If the fan assembly has been so removed, omit paragraph 4-6 a below.

#### 4-6. Fan Assembly

##### a. Removal.

(1) Remove capscrews (1, fig. 4-8), lockwashers (2), nuts (4), and blade assembly (3).

(2) Remove fan belts (refer to TM 5-3810-290-12).

(3) Remove four capscrews (24), lockwashers (25), washers (26), nuts (29), and fan hub assembly from bracket (21).

(4) Remove four capscrews (23), lockwashers (22), and bracket (21).

(5) Remove four capscrews (20), lockwashers (19), and support (18) from front of engine assembly.

(6) Remove nut (29), washer (26), capscrew (24), and bracket support (30) from front of engine assembly.

##### b. Disassembly.

(1) Remove six capscrews (5), lockwashers (6), and hub extension (7).

(2) Remove the cap (8). Remove the bolt (9) and washer (10).

(3) Tap the shaft (27) with a soft hammer and withdraw the shaft from the pulley and hub assembly (15).

(4) Remove the oil seal (17), bearing (16), bearing (11), shims (12), retainer (13), and spacer (14).

##### c. Cleaning, Inspection, and Repair.

(1) Clean the blade assembly and fan hub parts with an approved cleaning solvent. Dry with compressed air.

(2) Inspect the V-belts for cracks and signs of excessive wear. Replace as required.

#### CAUTION

Always replace the V-belts as a set.

(3) Inspect the fan and crankshaft pulleys for

damage and excessive wear. Remove any rough or rust spots with crocus cloth. Replace the pulley(s) as required.

(4) Inspect the blade assembly for cracks or bent blades. If blades are badly bent, replace the assembly. Do not attempt to straighten.

(5) Hold the inner race of the bearings and rotate the outer race slowly by hand. If rough or tight spots are detected, replace the bearing.

##### d. Assembly.

(1) Apply a good grade of GAA grease to the rollers of both bearings before installing them in the pulley (15).

(2) Install the inner bearing (16) with the protruding face of the inner race facing outward from the hub.

(3) Install a new oil seal (17) with the felt-side flush with the outer edge of the hub.

(4) Place the hub over the shaft (27) and install the bearing spacer (14).

(5) Pack the cavity approximately  $\frac{1}{4}$  full with all purpose grease and install the grease retainer (13).

(6) Place the shims (12) against the bearing spacer. Then, install the outer bearing (11) with the protruding face of the inner race facing outward from the hub.

(7) Secure the hub with the retaining washer (10) and bolt (9). Tighten the bolt to 83-93 pound-foot torque while rotating the pulley.

(8) Check the end play in the assembly with the shaft in a horizontal position. The end play must be within 0.001 to 0.006 inch. If necessary, remove the bolt, washer, and outer bearing and adjust the number and thickness of shims to obtain the required end play. Shims are available in 0.015, 0.020, and 0.025 thickness. Then reassemble the fan hub and check the end play.

(9) Fill a new fan hub cap  $\frac{3}{4}$  full of grease and install it in the end of the fan hub (pulley).

(10) Install the hub and shaft assembly on the bracket (21), attach with bolts (24) and washers (25 and 26). Do not tighten the bolts.

(11) Install the hub extension (7) on the hub and pulley assembly. Secure with bolts (5) and lockwashers (6).

##### e. Installation.

(1) Install the fan assembly on the engine in reverse order of removal.

(2) Adjust fan belt tension.

## Section IV. WATER PUMP AND IDLER PULLEY ASSEMBLIES

### 4-7. General

a. The water pump is a centrifugal-type (impeller) pump, mounted on top of the oil cooler housing and is belt driven by the left cam-shaft balance weight pulley. The sealed water pump shaft ball bearing is filled with lubricant when assembled and no further lubrication is required. Coolant is prevented from creeping along the shaft toward the bearing by a seal. The coolant is drawn from the radiator by the pump and circulated through the engine oil cooler, cylinder block, cylinder head, thermostat housing and back to the radiator. A portion of the coolant is diverted from the thermostat housing and passes through the engine coolant filter and returned to the water pump.

b. The water pump idler pulley assembly is mounted on the upper engine front cover, and provides a means of adjusting the water pump drive belts tension.

### 4-8. Water Pump

a. *Removal.* Remove the water pump as instructed in TM 5-3810-290-12.

#### b. *Disassembly.*

(1) Match mark pulley and shaft assembly. Remove pulley (14, fig. 4-9) with a suitable puller.

(2) Remove seven bolts with assembled washers (1). Remove cover (2) and gasket (3). Discard gasket.

(3) Press out shaft assembly (6), seal (5), and impeller (4) from body (13).

### CAUTION

Use adapter to apply pressure on bearing outer race. Do not press on end of pump shaft.

(4) Press end of shaft assembly (6) out of impeller (4). Remove seal (5) from pump shaft. Discard seal.

#### c. *Cleaning, Inspection, and Repair.*

(1) Clean all parts with an approved cleaning solvent except the shaft assembly. Dry with compressed air.

### NOTE

A permanently lubricated and sealed bearing is used in the shaft assembly and is not to be washed. Wipe the bearing and shaft assembly with a clean lint-free cloth.

(2) Inspect impeller for damage and excessive wear on impeller face which contacts seal. Replace impeller if worn or damaged.

### NOTE

The clearance between the inner edge of the impeller and the pump body should be 0.010—0.022 inch.

(3) Rotate shaft bearing slowly by hand. If rough or tight spots are detected, replace shaft assembly.

### NOTE

A replacement kit containing those items denoted by an asterisk (\*) in figure 4-9 is available for repair and overhaul of the water pump.

#### d. *Assembly.*

(1) Press shaft assembly (6) into pump body (13) until outer race of bearing is flush with outer face of pump body. Apply pressure on outer bearing race only.

(2) Lightly coat outside diameter of new seal (5) with seal compound. Install seal in pump body by applying pressure on seal outer flange. Press it until flange contacts pump body.

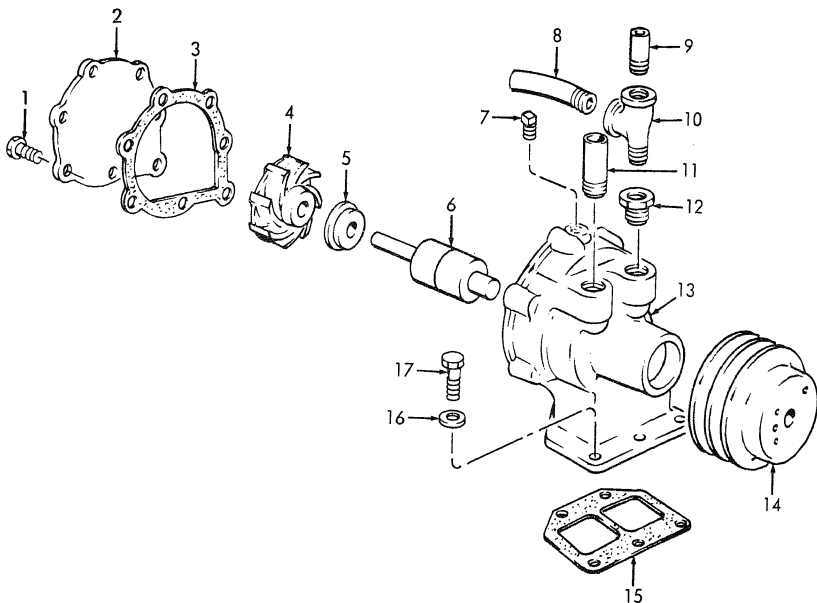
(3) Support pulley end of shaft and press impeller (4) on shaft until impeller is flush with pump body.

(4) Place pulley (14) on bed of arbor press and press shaft into pulley until pulley is in its original position on shaft.

(5) Install cover (2) and new gasket (3) and secure with seven bolts and assembled washers (1). Tighten the bolts to 6-7 pound-feet.

(6) Run the assembled pump dry at 120 revolutions per minute for one minute to insure satisfactory seating of the seal.

e. *Installation.* Install the pump on the engine in the reverse order of removal.



ME 3810-290-34/4-9

1. Bolt (7)
2. Cover
3. Gasket \*
4. Impeller \*
5. Seal \*
6. Shaft \*
7. Pipe plug
8. Nipple
9. Nipple
10. Tee
11. Nipple
12. Bushing
13. Body
14. Pulley
15. Gasket \*
16. Lockwasher (4)
17. Bolt (4)

\* Components available in repair kit.

Figure 4-9. Water pump, exploded view.

#### 4-9. Water Pump Idler Pulley Assembly

a. *Removal.* Remove the idler pulley assembly (refer to TM 5-3810-290-12).

##### NOTE

The pulley assembly includes the pulley adjusting

bracket, and shaft and bearing assembly which are not serviced separately.

b. *Disassembly.*

(1) Support the pulley in an arbor press, and

press out the shaft and bearing assembly and bracket by applying pressure on outer race of bearing.

(2) Support the bracket and remove the shaft and bearing assembly by pressing on shaft only.

*c. Cleaning, Inspection, and Repair.*

(1) Clean the bracket, pulley, and hardware with an approved cleaning solvent. Dry thoroughly with compressed air.

**CAUTION**

**Do not immerse the shaft and bearing assembly in any cleaning solvent.**

(2) Inspect the pulley and bracket for excessive wear or cracks. Replace idler pulley assembly as required.

(3) Revolve the shaft in the bearing slowly by hand. If rough or tight spots are detected, replace idler pulley assembly.

*d. Assembly.*

(1) Press the bearing and shaft assembly into the pulley by applying pressure on the outer race of bearing until outer race of bearing is flush inside surface of pulley.

(2) Press shaft and bearing assembly into bracket, apply pressure on shaft and press in until the distance between the edge of the pulley and bracket is 0.160 inch.

*e. Installation.* Refer to TM 5-3810-290-1 for installation of the water pump idler pulley assembly.

## Section V. ENGINE ALTERNATOR

### 4-10. General

*a. The battery-charging circuit consists of an engine-mounted, belt-driven alternator with built-in voltage regulator, batteries, and wiring. A reverse voltage polarity relay is included in the circuit for additional protection. The alternator output is 60 amperes at 28 volts. Alternating current rectification is provided by long-life silicon diodes, and voltage regulation can be adjusted externally with a conventional screwdriver.*

*b. Before the alternator is removed for overhaul or rebuild, all external circuit elements (e.g., belt tension, wiring and terminal connections, and condition of battery) should be carefully checked for proper performance before assuming that the alternator is malfunctioning.*

*c. Removal, testing, and installation of reverse polarity relay is covered in TM 5-3810-290-12.*

### 4-11. Alternator

*a. On Vehicle Testing.* Before removing the alternator for repair or replacement, inspect the drive belts, mounting brackets, and wiring harness in the following manner:

(1) Check belts for proper tension, excess wear, or the presence of oil or grease which could cause them to slip. Check the pulleys for discoloration which would indicate overheating due to belt slippage. Inspect pulleys for wear which could allow belts to bottom in the pulley grooves. Replace any worn or defective parts.

(2) Check mounting brackets and tension adjusting arm. Wear or looseness of these parts will prevent proper belt adjustment and may result in misalignment which will cause premature wear on

belts, pulleys and bearings. Tighten or replace as necessary.

(3) Inspect all wiring and terminals for wear, looseness or corrosion. Check for worn or frayed insulation which could result in short circuits to ground. Clean and tighten all terminal connections.

(4) Check batteries. Take a specific gravity reading on each cell. Replace batteries which indicate one or more defective cells.

(5) After the above checks and adjustments have been performed, an electrical check must be made. An accurate voltmeter will be required.

*(a)* Remove the alternator terminal cover and expose the "B+" terminal and check the voltage across this terminal and alternator ground (fig. 4-11D). If the vehicle is equipped with a master battery switch, turn this on. Full battery voltage should be present. If not voltage is present across the "B+" terminal and ground, an open circuit between alternator and battery is indicated. This may be due to loose or broken wiring or possibly a defective circuit breaker, master switch, or ammeter. Correct any defects before proceeding to the next test. Full battery voltage must be present across alternator positive terminal as well as the alternator ignition terminal when the ignition switch is turned on.

*(b)* Reconnect the voltmeter across the "B+" terminal and alternator ground (fig. 4-11D). The engine should now be started and run at a speed which will maintain approximately 2000 rpm.



ical accessories should now be turned alternator output is approximately 10 point, the voltage should be 28.0. If above or below this reading, it should be as instructed on figure 4-11D). Voltage by turning screw counter-clockwise.

Be sure to replace the plug after it has been made to keep out the dirt. When vehicles are operating in extremely high temperatures are it may be necessary to reduce the event battery damage. Under these voltage should be reduced to a point to remain charged but do not overheat give amounts of water.

1d.

Remove the engine hood top panel (refer 0-290-12).

Disconnect alternator electrical load from relay (refer to TM 5-3810-290-12). Remove alternator drive belts (refer to 5-90-12).

Remove alternator adjusting bolt and two nuts (refer to TM 5-3810-290-12). Remove alternator from engine assembly.

Remove the following:

Remove pulley nut, guard washer, and drive end pulley.

#### NOTE

Do not immerse in water with protective jaws when removed.

Remove key and pulley spacer.

Remove the six socket head screws (38,

Remove drive end housing (29), regulator (1), and packing (23).

Remove the four screws (53) and the drive end housing (25) from the drive end housing.

#### NOTE

Do not immerse in water with protective jaws when removed. Do not immerse in water with protective jaws when removed.

Remove the bearing (26), packing (27), (8) from the drive end housing (29). Remove the two screws (22), guard and lockwashers (14) which secure the drive end housing (20), and remove the brush

holder. Remove the brushes (56) from the holder.

(8) Remove the screw (50), washer (49), and sleeve (48), from rotor shaft (41). Remove fan (47), and key (51) from shaft.

(9) Remove the six screws (52), and pull the end housing (45), and rotor assembly from the intermediate housing assembly (10).

(10) Remove the end housing (45) from the rotor shaft. Remove the bearing (44).

#### NOTE

The bearing may remain on the rotor shaft or in the housing. Removal procedure will be controlled by its location.

(11) Press the seal (39) out of the intermediate housing (10).

#### NOTE

Replace with new seal when assembling.

(12) Further disassembly of the unit is not required unless tests listed in paragraph e below indicate a defective component.

#### d. Cleaning, Inspection, and Repair.

(1) Clean all parts with an approved cleaning solvent. Dry thoroughly with low-pressure compressed air.

#### NOTE

Do not immerse electrical components in solvent. Wipe as clean as possible with dampened cloth.

(2) Inspect bearings (26 and 44) for wear. If total radial clearance of either exceeds 0.003—0.005 inch, replace the bearing(s).

#### e. Testing.

(1) Slide the three insulating sleeves away from the splices and unsolder the connections to the stator leads.

(2) Connect a series test light between each stator lead and the core. Lighting of the test lamp indicates a grounded coil which will necessitate the replacement of the stator.

(3) Connect the test lamp between each stator lead for a continuity check. An open circuit will require replacement of the stator.

(4) The positive heat sink is insulated from the housing. A continuity check with test lamp or ohmmeter will indicate the need for replacing insulators and bushings.

# RECTIFIER CELL POLARITY MARKINGS



Positive Terminal Post  
Cells Used in Positions  
4-5-6 Have Symbol Stamped  
as Shown. The Symbol or  
Arrow Marking Always  
Points to the Positive  
Side of the Rectifier.

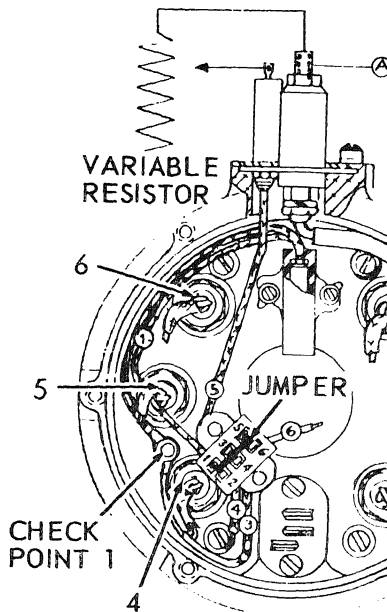


NEGATIVE CASE  
Negative Terminal Post  
Cells Used in Positions  
1-2-3 Have Symbol Stamped  
as Shown. The Symbol or  
Arrow Marking Always  
Points to the Positive  
Side of the Rectifier.

## POSITIVE CASE

CAUTION: DO NOT USE COLOR CODING  
TO DETERMINE POLARITY

A



B

## IMPORTANT

Before Assembling Lip  
Seal, Cavity to be  
Filled 40 to 50% With

NOTE:

PIPE PLUG

IGNITION  
LEAD

VOLTMETER

V

(5) The negative heat sink is grounded to the housing through its mounting screws. All connections must be clean and secure.

(6) Test the positive diodes (A, fig. 4-11) by connecting the negative lead of an ohmmeter to check point 2 (B, fig. 4-13) and the positive lead to terminals 1, 2, and 3. A low resistance reading should be obtained. Reverse the ohmmeter leads. A high resistance reading should be obtained. If a low resistance reading is obtained, the diode is short circuited and must be replaced.

(7) Check the diodes in the negative heat sink by connecting the negative test lead of an ohmmeter to check point 1 and touching the positive lead to terminals 4, 5, and 6 (B, fig. 4-11). A low reading indicates a defective diode and consequent replacement.

(8) In case the above electrical components check out satisfactorily, replace the voltage regulator assembly (25, fig. 4-10).

#### NOTE

Do not attempt to repair the voltage regulator assembly.

(9) To replace a defective diode, unsolder the lead and remove the rubber sealant from around the diode. Unscrew the diode; check the mounting surface of the heat sink for burrs or foreign material which might prevent the new diode from seating properly.

#### CAUTION

Observe the correct polarity when replacing diodes. Otherwise, serious damage will result. Reference A, figure 4-11.

(10) Insert the new diode and tighten to a torque of 20—25 inch pounds. Resolder the lead to

(11) When n assembly, unsolder close as possible on housing (10, fig. assembly (42) from

(12) Carefully which seals the three the new stator assembly the fiber insulator and the leads with new

(13) Test the grounding. An ohm collector rings should reading does not fail coil is defective. Co collector ring and the defective rotor coil.

#### *f. Assembly.*

(1) Assemble order of disassembly when inserting the stator and intermed the collector rings

(2) Press the r on the rotor shaft. U alinement of the si (25) with the conn

Before assemb illustrated (C,

(3) Install the Install the guard w pulley nut. Torque

*g. Installation.* reverse order of r tension (refer to T

(2) Loosen clamp between flexible pipe and exhaust manifold (5, fig. 4-23).

(3) Remove exhaust manifold (para 4-25).

**CAUTION**

**Remove battery cables before removal of electrical leads.**

(4) Tag and disconnect all electrical leads to the starting motor and solenoid.

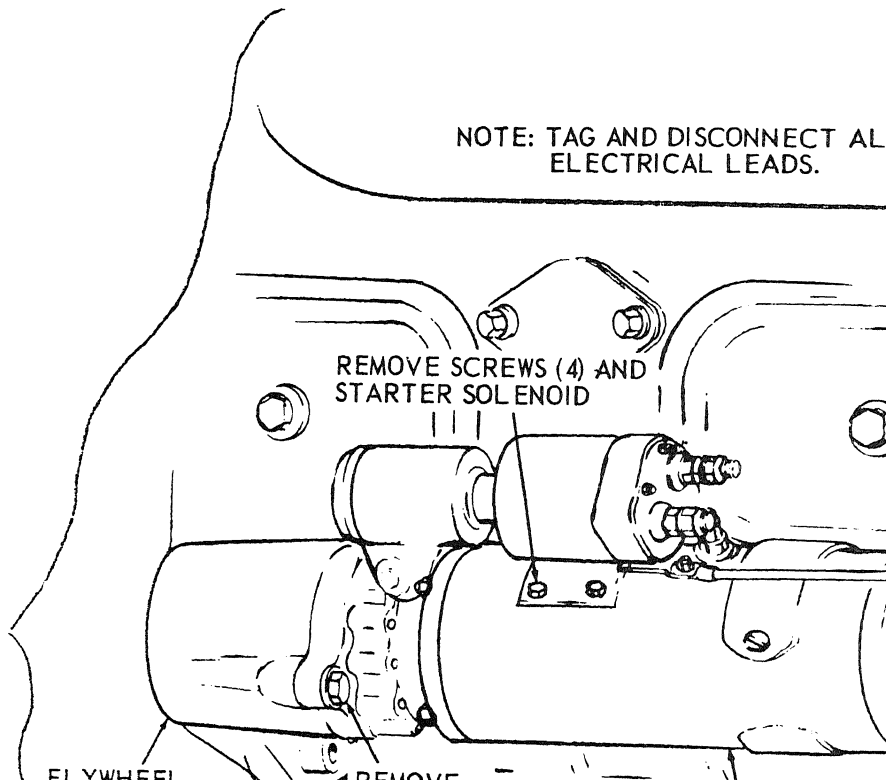
(5) Remove three capscrews and washers that

secure starting motor (fig. 4-24, para 4-12).

(6) Slide the starting motor forward to clear both the air filter and the air housing.

(7) Lift starting motor out of the engine compartment opening provided by the right and left bottom hood.

**NOTE: TAG AND DISCONNECT ALL ELECTRICAL LEADS.**



lever housing (32, fig. 4-13)., and drive housing (28) so that parts may be properly oriented during assembly.

(2) Remove six socket head capscrews (26, and 27, fig. 4-13) and pull drive housing (28) from starter. Remove and discard gasket (30).

(3) Loosen terminal screw on solenoid relay terminal. Remove nut (46, fig. 4-13), lockwasher (47), and terminal and lead (1, fig. 4-13).

(4) Remove four screws (39), two inspection covers (38), and discard gaskets (40).

(5) From each inspection opening, remove one screw (62, fig. 4-13) and lockwasher (64) that attaches the field coil lead as well as a brush. Mark the two holes for identification upon assembly of the starter.

(6) Remove four screws (42, fig. 4-13) and lockwashers (41), and pry the commutator end plate and brush holder assembly (fig. 4-13) loose from the frame.

(7) Before further disassembly, test brush spring tension (65) using a suitable spring scale. Tension must not be less than 80 ounces.

(8) Remove the six remaining screws (62) and lockwashers (64), and remove eight brushes (63).

(9) Remove nut (48), lockwasher (47), and washer (49) from terminal stud.

(10) Remove three screws (72), lockwashers (73), and washers (74), and separate end frame (52) from commutator plate assembly (54). Remove two insulating washers (53) from terminal stud.

(11) Remove insulator (50) and bushing (51) from end frame only if replacement is necessary.

(12) Remove two grounded brush holder screws (68), screws (69), lockwashers (70), and

lever (19). Turn nut (20) clockwise to pull plunger and spring (18) out of lever housing.

(20) Remove nut (20), spring (18), retainer (16), spring (17), plunger and boot (13), and washer (14).

(21) Remove nut (21), spring (22), and shaft (23) from lever housing. Remove preformed packing (24) from lever (19).

(22) Remove nut (22), spring (23), and shaft (24) from lever housing. Remove four screws (25) from solenoid switch from lever housing.

(23) Pull armature (26) from lever housing. Remove screws (27) from armature shaft and lever housing end.

Do not remove field coil lead (para c below) in this step.

(24) Remove insulating washers (53) from terminal stud.

(25) Using a socket wrench, remove attachment, remove screws (62) and lockwashers (64) from end frame.

A press ram may be used to remove wrench and drive screws (62) and lockwashers (64) from end frame.

(26) Remove field coil (44) and insulator (45) from lever housing bushing (4).

Take care not to scratch coil or scratch coil. *c. Cleaning, Inspection, and Lubrication.*

(1) Clean solenoid and frame with a cleaning solvent. Do not use

ing, or rough spots with fine crocus cloth  
ed in dry-cleaning solvent. Replace a drive  
ch assembly that has a defective pinion gear,  
ked or otherwise damaged parts, or inside  
meter of drive clutch bushings exceeds the limit.

# NOTE

A new drive clutch bushing measures 0.6240—  
0.6250 inch inside diameter.

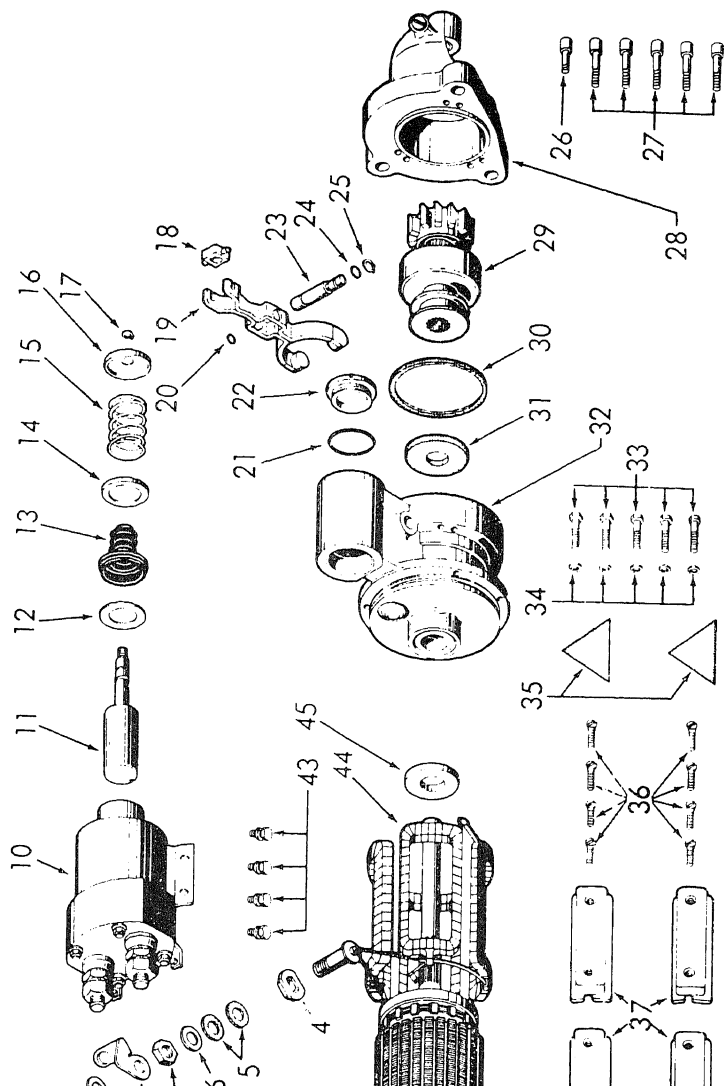
(8) Inspect shift lever housing (32, fig. 4-13)  
cracks, warpage, scoring, burs, and nicks on  
hined surfaces. Smooth scoring, burs, and  
or nicks with fine crocus cloth dipped in  
cleaning solvent. Replace a housing that is  
ked, warped or badly damaged.

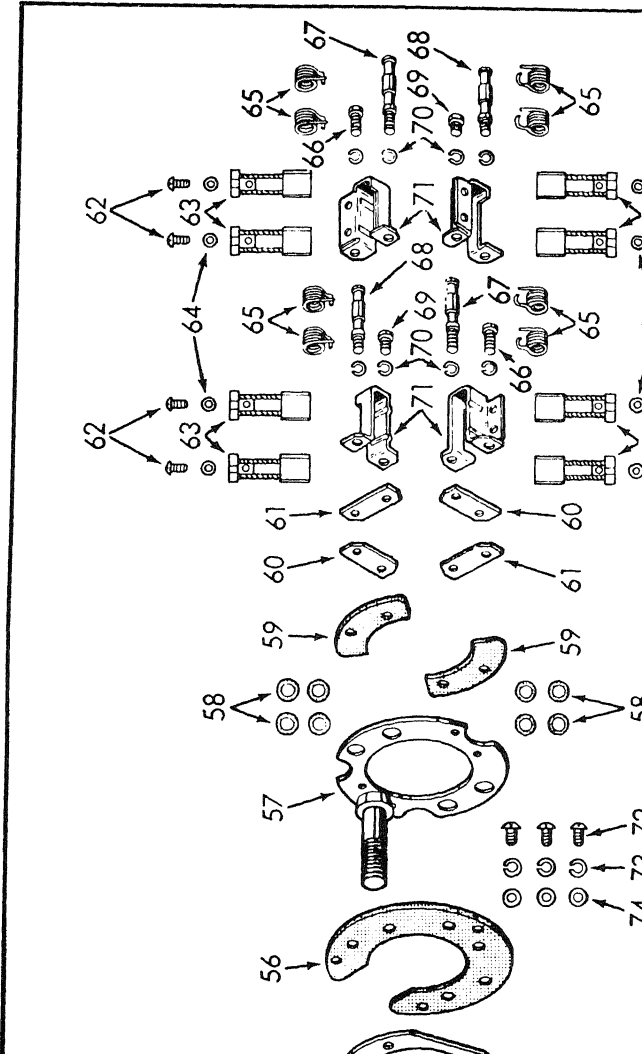
(9) Check inside diameter of lever housing  
hing. If diameter is greater than 0.8355 inch,  
ace bushing. A new bushing measures 0.8335-  
8355 inch inside diameter.

(10) Inspect shift lever (19, fig. 4-13) for  
cks or distortion. Diameter of shaft bore must  
exceed 0.5120 inch, (0.5100-0.5120 inch when  
). Replace a damaged shift lever or one with a  
e diameter greater than 0.5120 inch.

# KEY to fig.

1. Termi
2. Wash
3. Armat
4. Bushi
5. Wash
6. Wash
7. Nut (
8. Conne
9. Lockw
10. Solen
11. Plung
12. Wash
13. Boot
14. Spring
15. Spring
16. Spring
17. Retain
18. Nut
19. Shift
20. Prefor
21. Cask







KEY to figure 4-13 (sheet 2 of 2)

- 46. Nut
- 47. Lockwasher (2)
- 48. Nut
- 49. Washer
- 50. Insulator
- 51. Bushing
- 52. End frame
- 53. Washer (2)
- 54. Commutator plate assy
- 55. Plate
- 56. Insulator plate
- 57. Plate and stud
- 58. Bushing (8)
- 59. Insulator (2)
- 60. Plate
- 61. Plate (2)
- 62. Screw (8)
- 63. Brush (8)
- 64. Washer (8)
- 65. Spring (8)
- 66. Screw (2)
- 67. Screw (2)
- 68. Screw (2)
- 69. Screw (2)
- 70. Lockwasher (8)
- 71. Brush holder (4)
- 72. Screw (3)
- 73. Lockwasher (3)
- 74. Washer (3)

(11) Inspect spring (15) for cracked or broken condition. Approximate free length of spring should be 2.7920 inches; a compression force of 13.5—14.5 pounds should compress spring to a length of 1.560 inches. Replace a spring that is broken, cracked, or fails to meet above requirements.

(12) Check diameter of shaft (23). Replace shaft if diameter is less than 0.4980 inch. A new shaft measures 0.4980—0.5000 inch in diameter.

(13) Inspect commutator end frame (52) for

(17) Inspect thrust spacer (washer) (48). Replace parts as required if spacer that is worn to less than .0020 inch thickness. A new thrust washer measures .0020 inch in thickness.

(18) Check armature for worn conditions; replace one of the conditions:

(a) Diameter of commutator end worn to less than .0020 inch. A new shaft measures 0.6220—

(b) Diameter of housing shoulder portion .0020 inch. A new housing measures 0.8225 inch. A new housing measures 0.8240 inch at this point.

(c) Diameter of shaft that is worn to less than .0020 inch. A new shaft measures 0.6220—

(d) Diameter of housing 2.1930 inches. A new housing measures 2.3180 inches at this point.

(e) Check condition, a manual limit of 0.0020 inch.

(19) Inspect armature light by placing on test light and the other test point. If test light glows, the armature should be replaced.

(20) Inspect armature growler fixture. M

(c) If commutator is turned down to a diameter of 2.1930 inches and is still unsatisfactory, replace armature.

(d) After resurfacing the insulation (mica) between the commutator bars must be undercut to a depth of 0.025—0.032 inch below surface of commutator.

#### NOTE

Use care in undercutting. Do not widen commutator slots by removing metal from bars and do not leave a thin edge of mica next to bars.

(e) After undercutting mica, remove all copper and mica particles with compressed air. Polish commutator with no. 00 sandpaper while rotating in a lath of 1500 revolutions per minute.

(22) Inspect starter frame for cracks, distortion, or stripped threads. Replace a defective frame.

(23) Check field coils for ground by attaching one lead of a test lamp to the starter frame and the other lead to a coil connector. If the test lamp glows, the coil is grounded and should be replaced.

(24) Check for open coil by connecting test lamp leads to ends of field coils. If lamp does not light, the field coil is open and must be replaced.

#### *d. Assembly.*

(1) Install bushing (4, fig. 4-13) on field coil (44) terminal stud and position field coil in frame. Secure terminal stud with two insulating washers (5), washer (6), and nut (7).

(2) Position two insulators (35) between field coil and frame.

(3) Position each of the pole shoes (37) on coil inside frame. Aline mating holes and secure with pole shoe screws (36).

#### NOTE

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shift lever

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(11) S

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engage

(13) S

capscrews

(14) F

(56), and

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bushings (5

and stud (

(15) F

two brush

secure with

each.

(16) I

(70) on ea

hole of br

(17)

holders (71

(57) and

washer (70

(18) I

(70) on ea

hole of br

(22) Position thrust washer (2, fig. 4-13) on commutator end of armature (3) shaft and install commutator end plate and brush holder assembly on armature shaft.

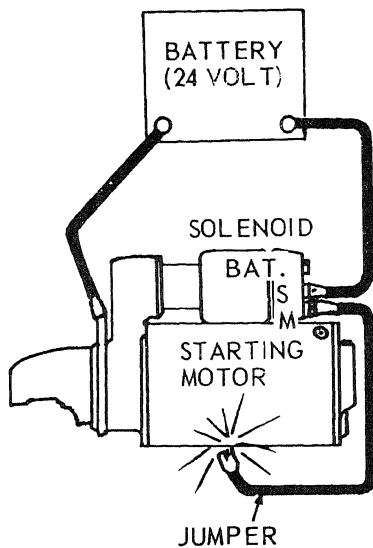
(23) Raise springs (65, fig. 4-13) and install brushes (63). Secure six of the brush leads with screws (62) and lockwashers (64), omitting brush lead connection for two brushes that will connect to field coils as marked during disassembly (para 4-13 b (5)).

(24) Install washer (45, fig. 4-13) on splined end of armature shaft and install assembled ar-

mature, commutator and brushes, as a unit, in position (para 4-13 b (1)) on armature shaft with four screws (46).

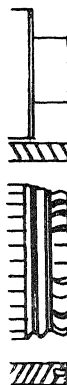
(25) Align holes in commutator end plate and brush holders and secure with two screws (47) and lockwashers (64).

(26) Position brush holder covers (38), and secure with screws (48).

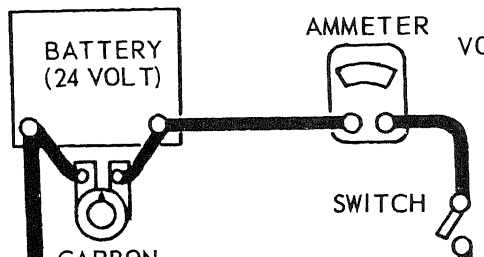


A. CIRCUIT FOR CHECKING PINION CLEARANCE

SHAFT  
(TURN  
PINION



B. C



groove of drive housing (28). Slide drive housing over drive clutch (29) and align scribe marks on drive housing and lever housing.

(29) Install screw (26) in blind tapped hole. Install five screws (27) in remaining holes of drive housing. Torque all six screws to 13-17 pound-feet.

*e. Adjustment.*

(1) Break all external connections between solenoid switch and starter.

(2) Remove inspection plug (22, fig. 4-13) and gasket (21).

(3) Connect starter motor to battery as shown in figure 4-14A.

(4) Momentarily flash jumper cable (fig. 4-14A). The pinion will now shift into cranking position and remain so until battery is disconnected.

(5) Adjust pinion clearance as instructed on figure 4-14B.

*f. No-Load Test.*

(1) Provide test hook-up for starter as shown in figure 4-14C.

(2) Adjust carbon pile to provide a voltage reading of 23 volts.

(3) Armature speed should be 7000 rpm minimum, 10,700 rpm maximum. Current draw must be 60 amperes minimum and 90 amperes maximum.

(4) Low free speed and high current draw indicate:

(a) Too much friction—tight, dirty, or worn bearings, bent armature shaft or loose pole shoes allowing armature to drag.

(b) Shorted armature. This can be checked with growler (para 4-13 c(20)) after disassembly.

(c) Grounds for grounds (p) disassembly.

(5) Failure indicates:

(a) A di

(b) Froz

(6) Failure indicates:

(a) Open connections and 4-13 c(24)).

(b) Open commutator f disassembly.

(c) Poor commutator. Ch brushes, high in

(7) Low no indicates a high connections, def causes listed in

(8) High f indicate shorted repeat test.

*g. Installatio*  
reverse order of  
137—147 poun

Use care in  
manifolds,  
jarred or  
installed an

(6) Disconnect two coolant hoses from compressor cylinder head.

(7) Remove two bolts and flat washers that secure compressor support bracket to engine upper front cover.

(8) Remove four capscrews, lockwashers, and nuts that secure the compressor crankcase to the engine mounted base.

(9) Lift compressor up and forward from engine.

*b. Disassembly.*

NOTE

Before disassembly, the cylinder head, cylinder block and crankcase should be marked to maintain their relationship upon reassembly.

(1) Remove two screws and lockwashers that secure the governor (fig. 4-15) to the compressor. Discard the gasket.

(2) Unscrew cover (2, fig. 4-15).

(3) Remove retaining ring (4) and lift out the adjusting screw and spring assembly.

(4) Remove nut (3), spring seat (5), spring (6), two spring seats (7) and spring guide (8) from adjusting screw (9).

(5) Remove exhaust stem (10) and spring (1) from piston (17).

(6) Invert the body (13) and tap lightly to remove the piston assembly (17).

(7) Remove the spring (14), valve (15), and preformed packings (16 and 18) from piston (17). Discard the preformed packings.

(8) Remove plugs (11) and filters (12) as necessary for cleaning and replacement.

(9) Remove the locknut (34, fig. 4-16), remove the pulley and key (59) from the crankshaft with suitable puller.

Be sure to  
connecting

(15) Pus  
tached out the  
the upper bea

(16) Use  
the piston rin

(17) Ren  
press wrist p  
connecting ro

Wrist pin  
warranted  
paragraph

(18) Ren  
(15), end cov  
from crankca

(19) Pre  
(28), removin

(20) If r  
bushing (35)  
and bushing  
(17).

(21) Ren  
that secure th  
block. Discar

(22) Ren  
washers (60),  
head. Remov

(23) Dep  
(56), spring s  
cylinder block

(24) Lift  
(54) from the  
applied to the

one port to the cooling passages. To the remaining port apply a source of compressed air. Immerse entire cylinder head in water. If a steady stream of bubbles is detected, replace cylinder head.

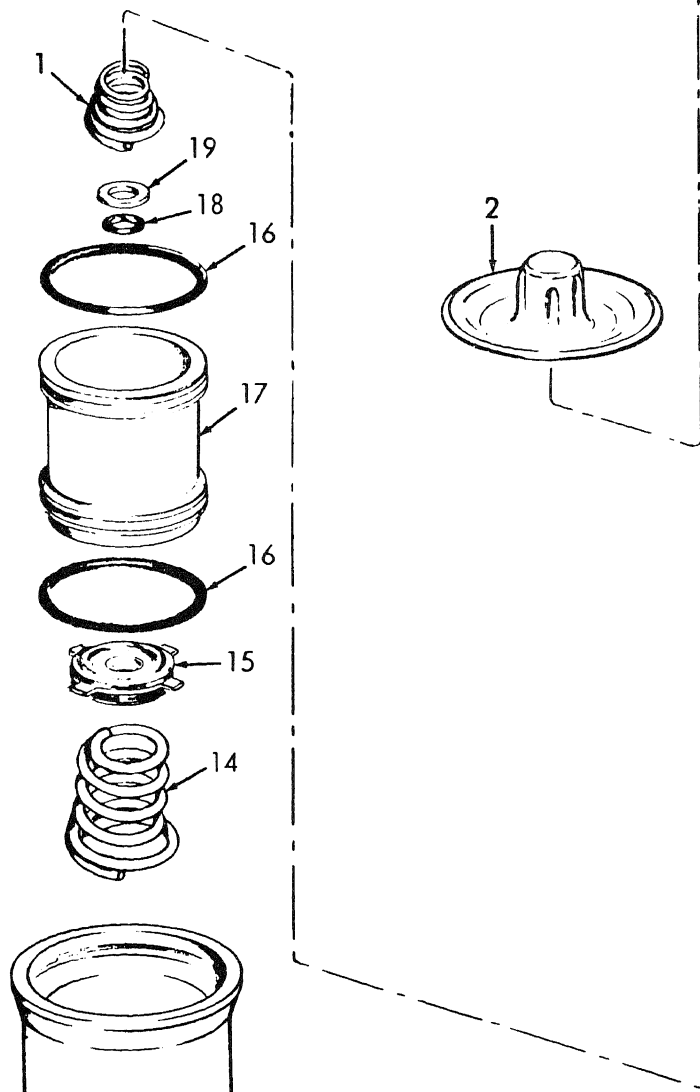
(3) Assembly discharge valves (47), with new springs (48) and new valve caps (3) into cylinder head. Valve travel should be between 0.056-0.070 inch. Apply 100 pounds of air pressure through cylinder head discharge port and apply soapy water at the discharge valves and seats. A slight leakage is permissible. If leakage is excessive, continue to apply air pressure, and with a fiber or hardwood dowel and hammer, tap the valves off their seats several times. This should help seat the valves, and reduce any leakage. If excess leakage continues, the valve seats can be dressed by lapping with a

suitable stone. If leakage persists, replace valves (47). With air pressure applied to cylinder head, check for leakage at (3). No leakage should be detected.

(4) Clean and inspect the inlet and unloader passages.

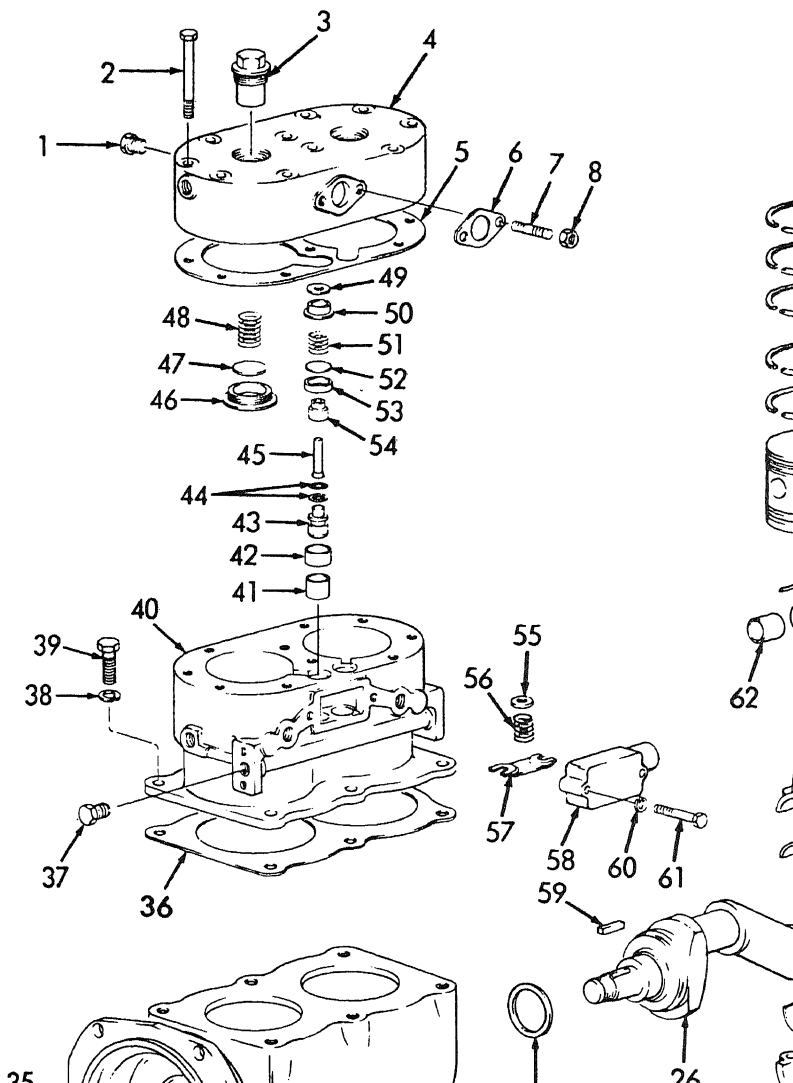
(5) If inlet valve shows signs of damage, they can be lapped with a fine stone or a lapping stone. Excessive lapping should be avoided.

The dimension  
(40) to the inlet  
0.145 inch nominal









Key to figure 4-16.

1. Pipe plug
2. Capscrew
3. Discharge valve capnut
4. Cylinder head
5. Gasket
6. Gasket
7. Stud
8. Nut
9. Piston rings
10. Wrist pin
11. Piston
12. Lock wire
13. Connecting rod
14. Upper bearing shell
15. Lockwasher
16. Capscrew
17. Cover
18. Pipe plug
19. Gasket
20. Bushing
21. Thrust washer
22. Lower bearing shell
23. Bearing cap
24. Lockwasher
25. Bolt
26. Crankshaft
27. Thrust washer
28. Crankcase
29. Gasket
30. Cover
31. Machine screw
32. Capscrew
33. Lockwasher
34. Nut
35. Bushing
36. Gasket
37. Pipe plug
38. Lockwasher

(7) Check for wear, rust or damage. If replaced, run a  $\frac{1}{8}$  inch bushing straight

Do not use an oversize bore bushings.

(8) Cylinder bore round by more than 0.003 inch oversize.

Clearance between rings should be 0.002 inch or less, if available.

(9) Check for enlarged ring grooves, scored, cracked, or worn. Measure each piston to its respective clearance given.

(10) Wrist pin pistons. If wrist pin both should be round and connecting rod check clearance between rod bushing. Clearance 0.003 inch. Replace wrist pin if clearance is found.

Wrist pin bushings pressed into

connecting rod (13) so that the lockwire hole in the pin alines with that of the piston. Install new lockwires (12) through piston and wrist pin and snap short end into hole provided at the bottom of the piston.

(4) Install piston rings (9) on piston with beveled edge toward the top of the piston. Stagger the ring gaps by at least 90 degrees.

#### NOTE

Piston rings should have a groove clearance of 0.002—0.004 inch. Gap clearance with ring installed on piston should be 0.005—0.015 inch.

(5) Lubricate the piston, piston rings, wrist pin, and connecting rod bearings with clean engine oil and insert assembly through the top of the cylinder block. Position the bearing cap (23) and using new lockwashers (24) tighten both bolts (25). Torque connecting rod bolts to 100 pound-inches and bend lockwasher tangs up against the hex head of the bolt.

(6) Install the other connecting rod and piston assembly in the same manner.

(7) The unloader pistons (43) and their bores must be lubricated with dimethyl polysilozane prior to installation.

(8) There should be a loose sliding fit between inlet valve guides (53) and the valves (52).

(9) If  
42) were r  
they fit wi  
above.

(10) I  
the cylinde  
springs (51  
grease.

(11) I  
the block  
assembly o

(12) I  
when insta  
cylinder bl

(13) U  
base cover  
(31), in se

(14) V  
governor (f  
the dimensi  
bottom of t  
1-7 / 8 inc

(15) I  
the cranks  
feet.

e. Insta  
engine in t

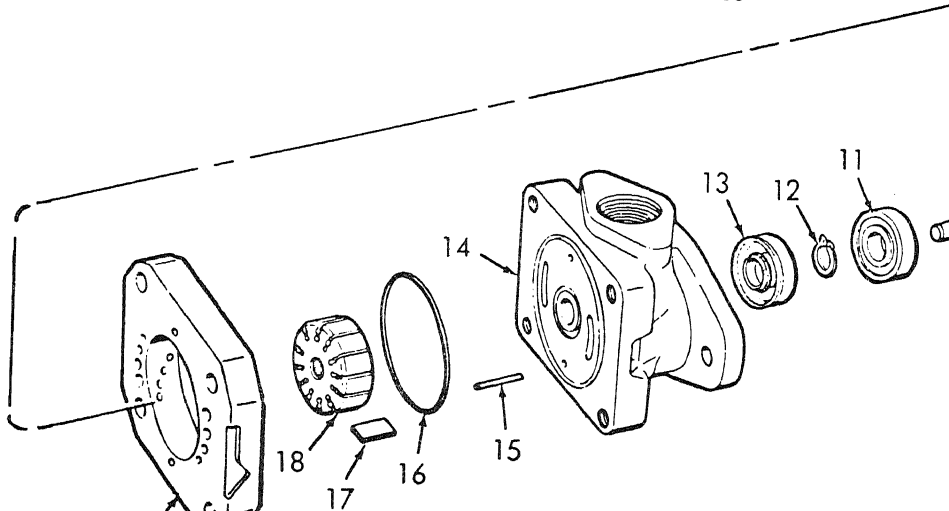
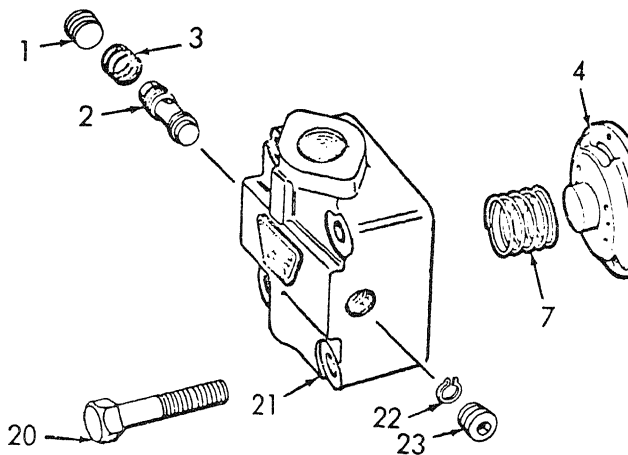
## Section VIII. HYDRAULIC POWER ST

### 4-16. General

The pump is mounted at the rear of the engine on the flywheel housing by means of an adapter plate, and is driven by an accessory drive assembly

(2) R  
(21) from

(3) R  
control val



(6) Support the shaft end of the pump body in an arbor press and remove the shaft assembly from the body.

(7) Remove the retaining ring (12) and bearing (11) from the shaft (10).

(8) Remove the shaft seal (13) from the body.

*c. Cleaning, Inspection and Repair.*

(1) Clean all parts with an approved cleaning solvent. Dry thoroughly.

**NOTE**

Discard all gaskets and preformed packing and replace with new units when assembling. Gasket and cartridge kits are available for repair.

(2) Inspect all surfaces of parts that are subject to wear. Remove light scoring by lapping, otherwise, replace respectively parts. Inspect edges of vanes (17) for wear. Excessive play in slots or burred edges will necessitate the replacement of the cartridge kit.

(3) Install the control valve (2) in the cover (21). Replace if any binding or scoring is observed.

(4) Install a new shaft seal (13) in the body. Do not over-press seal, however, seal must be bottomed against shoulder inside body.

**NOTE**

Coat all parts with clean hydraulic oil prior to assembly.

*d. Assembly.*

(1) Assemble pump in reverse order of disassembly, using new gasket and preformed packing. Make sure that the ring (19) is installed with the arrow pointing in correct direction of rotation, and with the chamfered edge of the rotor (18) toward the pump body (14).

(2) Install the cover (21) and cover screws (20). Tighten cover screws to 65-75 ft. lbs.

*e. Test.*

(1) Mount h proceed as follows:

(a) Provide capable of driving

(b) Provide

(c) Install h reservoir.

(d) Install tester inlet port.

(e) Install h oil reservoir.

(f) Install h reservoir.

(g) Position reservoir level with fill with OE-10 en

(2) Drive pur gpm at 150° F (

To heat oil, loa cycles, until re (approx. 20 min

(a) Pump is 100 psi.

(b) To cor multiply the rated g 1200.

(3) Volumetri greater. Compute v actual gpm by rat

*j. Installation.*  
reverse of instructi 3810-290-12).

(3) Inspect drive adapter and drive cable adapter for damage or wear.

(4) Inspect machined surface of cover assembly for burrs and nicks. Remove rough spots with crocus cloth.

*d. Assembly.*

(1) Assemble shaft (6), slinger (7), key (12), and drive adapter (9) with drive cable adapter (13).

(2) Install the assembly with new gasket (8) on cover assembly (2). Secure with nuts (11) and lockwashers (10).

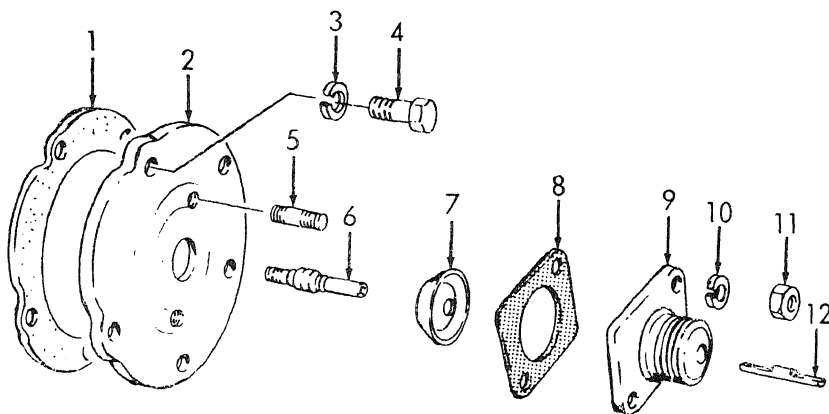
*e. Installation.*

(1) Insert end of

(2) Install the  
through cover assembly  
flywheel housing. The  
cover is seated square

(3) Connect flywheel  
adapter.

(4) Lubricate  
with current lubricant



1. Gasket

2. Cover

## TM 5-3810-290-34

coolant. To assure engine lubrication should the oil cooler become plugged, a by-pass valve permits oil to flow directly to the engine oil galleries from the oil pump.

### 4-21. Oil Cooler

#### *a. Removal.*

(1) Drain the cooling system by opening the drain cocks (7, fig. 4-19) on the bottom of the cooler housing.

(2) Loosen the clamps and slide the hose back on the water inlet elbow and tube to thermostat housing.

(3) Remove the water pump (Refer to TM 5-3810-290-12).

(4) Remove the bolts (6) and lockwashers (5).

(5) Remove the oil cooler.

#### *b. Disassembly.*

(1) Remove the core assembly (2) from the housing (4).

(2) Remove and discard the gaskets (1 and 3). Remove all traces of gasket material from the housing and cylinder block.

#### *c. Cleaning, Inspection, and Repair.*

(1) Clean all parts with an approved cleaning solvent. Dry thoroughly.

(2) Clean the oil passages in the cooler core (2) by circulating the trichloroethylene solution through the passages with a force pump.

### **WARNING**

Perform this operation in a well-ventilated area. Avoid breathing the

fumes or direct contact with the skin.

(3) Remove the solution by circulating an alkaline solution through the passages and flush with water.

Do not attempt to clean the system if failure has occurred. Remove metal particles from the system. Replace the

(4) Clean the solution by immersing in a 2½ percent two-thirds water and one-third ½ pound of oxalic acid solution. This will be completed in 24 hours after cessation of bubbling.

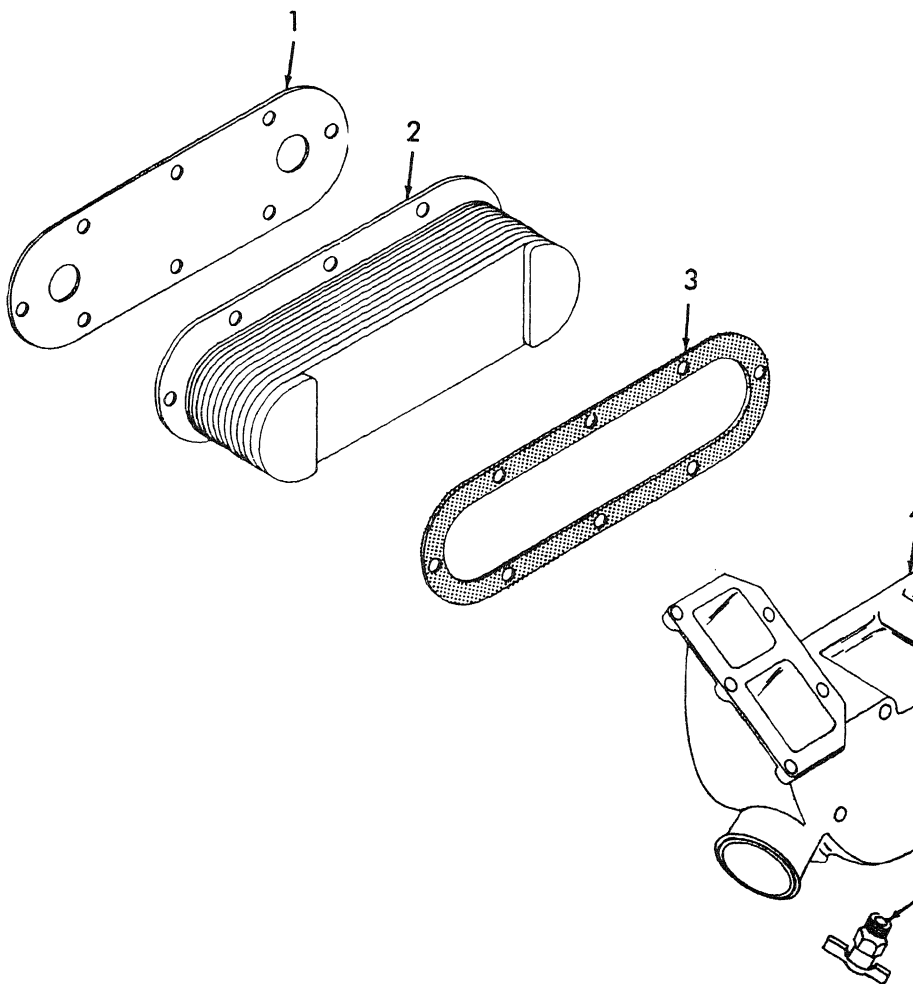
Avoid breathing the solution vapors.

(5) Thoroughly clean the water and dip the

(6) Test the core with a plate and rubber mallet. The flanged side of the core is a suitable source of a leak. The core in water. The leaky core which

When a leaking lubricating system





1. Outer gasket
2. Core assembly
3. Inner gasket
4. Housing

(7) Remove the core and dry thoroughly with compressed air.

*d. Assembly.*

**NOTE**

The inlet and outlet openings are stamped "IN" and "OUT". Replace the core in the housing in the same position as when it was removed.

(1) Clean all old gasket material from both faces of the core flange.

(2) Install new gaskets (1 and 3) to the faces of the core flange and insert in housing (4).

*e. Installation.*

(1) Position the oil cooler assembly on the cylinder block and secure with the bolts (6) and lockwashers (5).

(2) Tighten the bolts to 13—17 pound-feet torque.

(3) Install the water pump (refer to TM 5-3810-290-12) and hose connections.

(4) Close the drain cocks and fill the coolant system.

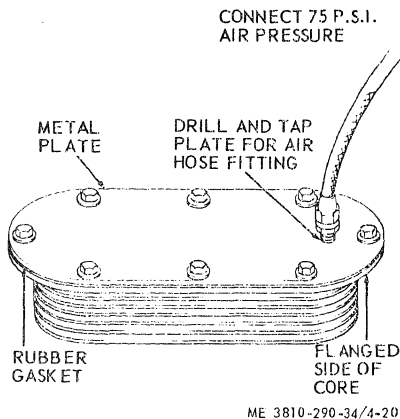


Figure 4-20. Oil cooler core prepared for leak test.

## Section XI. FUEL LINES AND FUEL PUMP

### 4-22. Fuel Lines

*a. General.* This section pertains to the fuel lines incorporated directly on the engine assembly. Fuel lines, to and from, the fuel tank are covered in TM 5-3810-290-12. These lines provide a means of transfer of fuel from the fuel pump to filter, filter to both cylinder heads, a crossover fuel line, and the connecting line for the fuel return.

*b. Removal.*

(1) Disconnect fuel supply hose from fuel pump and fuel return hose from reducer (4, fig. 4-21).

(2) Remove reducer (4), nipple (5), coupling (6), tube assembly (7), and elbow (8) from rear of the left cylinder head.

(3) Remove capscrew securing clip (3), swing the clip around and reinstall the capscrew.

(4) Remove capscrews (9), lockwashers (10) and clamps (11).

(5) Remove tube assembly (2) and elbows (1 and 19).

(6) Remove tube assemblies (13, 14, and 17) in that order, and remove adapters (12), tee (18), elbow (15), and 45° elbow (16).

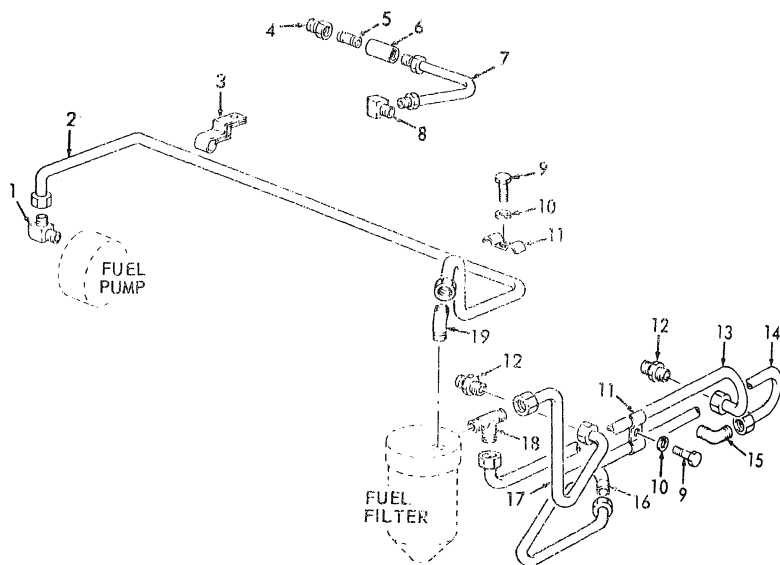
*c. Cleaning, Inspection, and Repair.*

(1) Clean all parts with an approved cleaning solvent and dry thoroughly.

(2) Inspect tube assemblies for cracks, kinks, and restrictions. Replace as required.

(3) Inspect all fittings for cracks, damaged threads or restrictions. Replace parts as required.

*d. Installations.* Install the fuel lines and fittings in the reverse order of removal. Do not overtighten tube connections.



ME 3810-290-34/4-21

1. Elbow
2. Tube assembly
3. Clip
4. Reducer
5. Nipple
6. Coupling
7. Tube assembly
8. Elbow
9. Capscrew (2)
10. Lockwasher (2)
11. Clamp (2)
12. Adapter (2)
13. Tube assembly
14. Tube assembly
15. Elbow
16. Elbow, 45°
17. Tube assembly
18. Tee
19. Elbow

Figure 4-21. Fuel lines and fittings, exploded view.

#### 4-23. Fuel Pump

a. *General.* The fuel pump is of the positive displacement gear type. The pump circulates fuel from the fuel supply tank to the fuel injectors. It is not a pressure pump. The pump circulates the excess supply of fuel through the injectors and the

unused portion goes back to the fuel tank by means of a fuel return manifold and fuel return line. A spring loader relief valve, incorporated in the pump body, normally remains in the closed position, operating only when pressure on the outlet side (to fuel filter) becomes excessive due to a clogged filter

or fuel line. The valve will open at a pressure of approximately 65 to 75 pounds per square inch, allowing fuel to return through a passage in the body from the pressure side to suction side of the pump. A small hole in the pump body allows fuel in back of the relief valve to bleed into the gear compartment. Otherwise, the fuel might become trapped and prevent the valve from opening. The fuel pump is mounted on the flywheel housing and driven by the fuel pump drive gear. The drive gear rotates on a stationary hub attached to the cylinder block and is driven at approximately twice engine speed by the right camshaft gear.

#### *b. Removal.*

(1) Drain fuel strainer and filter (refer to TM 5-3810-290-12).

(2) Disconnect fuel lines to pump.

(3) Remove three bolts (6, fig. 4-22) and copper washers (5). *Discard the washers.*

(4) Remove the fuel pump and fork (21) from flywheel housing. Remove and *discard gasket (3).*

#### **NOTE**

Removal and installation of pump drive gear is covered in paragraph 4-50.

#### *c. Disassembly.*

(1) Remove drive coupling (1) and fork (21) from drive shaft (8).

(2) Remove eight screws (1) and lockwashers (12). Remove cover (10) from pump body (4).

(3) Remove drive shaft (8), drive gear (9), and ball (15) as an assembly.

(4) Remove drive gear (9), if necessary. Do not lose ball (15).

(5) Remove drive gear and shaft assembly (13 and 14).

(6) Remove plug (20) and gasket (19). *Discard gasket.*

(7) Remove spring (18), pin (17), and relief valve (16).

(8) Remove oil seals (2) from pump body (4) with seal removing tool. *Discard seals.*

#### *d. Cleaning, Inspection, and Repair.*

(1) Clean all parts with an approved cleaning solvent and dry with compressed air.

(2) Inspect parts for damage or excessive wear. Replace as necessary. Check pump gear teeth for scoring or chipping. Replace if scored or chipped.

(3) Inspect mating faces of pump body and cover. Faces must be flat and smooth, and fit tightly together.

(4) Inspect relief valve for scoring. Remove score marks with fine crocus cloth, or replace valve.

#### *e. Assembly.*

(1) Place one oil seal (2) on the oil seal installer handle with the sealing edge against the shoulder of the handle.

(2) With the fuel pump body (4) supported on wooden blocks, insert the pilot of the oil seal installer handle into the pump so the seal starts straight into the pump flange. Then drive the seal into place in the counterbore of the flange until it bottoms.

(3) Install the oil seal installer adapter on the oil seal installer handle. Position the other seal (2) on the installing tool with the sealing edge facing the adapter. Insert the pilot of the installer handle into the fuel pump body (4) so the seal starts straight into the pump flange and drives the seal into the pump body until the shoulder of the adapter contacts the body.

(4) Reassemble the relief valve in the pump body by installing the valve body (16), spring (18), pin (17), gasket (19), and secure with the valve plug (20). Install the two pins (7) in the fuel pump body (4).

(5) Install the driven gear and shaft (13 and 14) in the pump body with the chamfered end of the gear teeth facing the pump body. Install the spur gear (9) over the squared end of the pump shaft (8), with the slot in the gear facing the plain end of the shaft. Press the gear beyond the bearing ball retaining hole. Press the bearing ball (15) in the hold and press the gear back until the end of the slot contacts the ball.

(6) Lubricate the fuel pump shaft and insert the squared end of the shaft into the opening at the gear side of the pump body and through the two oil seals (2).

#### **CAUTION**

**Coat the face of the pump cover with a very light coat of sealant, being careful to keep the sealant out of the gear compartment.**

(7) Lubricate the gears and shaft with clean engine oil, then position the fuel pump cover (10) against the pump body (4) with the two pins (7) in the pump body entering the holes in the cover, and secure the cover to the body with the eight lockwashers (12) and capscrews (11).

(8) Position the coupling and fork (1 and 21) on the squared end of the fuel pump shaft (8).

*f. Installation.* Install the fuel pump in the reverse order of removal.

*g. Performance Test.* After completing the installation of the fuel pump, check the performance of the fuel system.

(1) Make sure the strainer and filter elements have been replaced, and no restrictions are present in the fuel lines.

(2) Disconnect the fuel return at the fuel tank and insert the end in a suitable container.

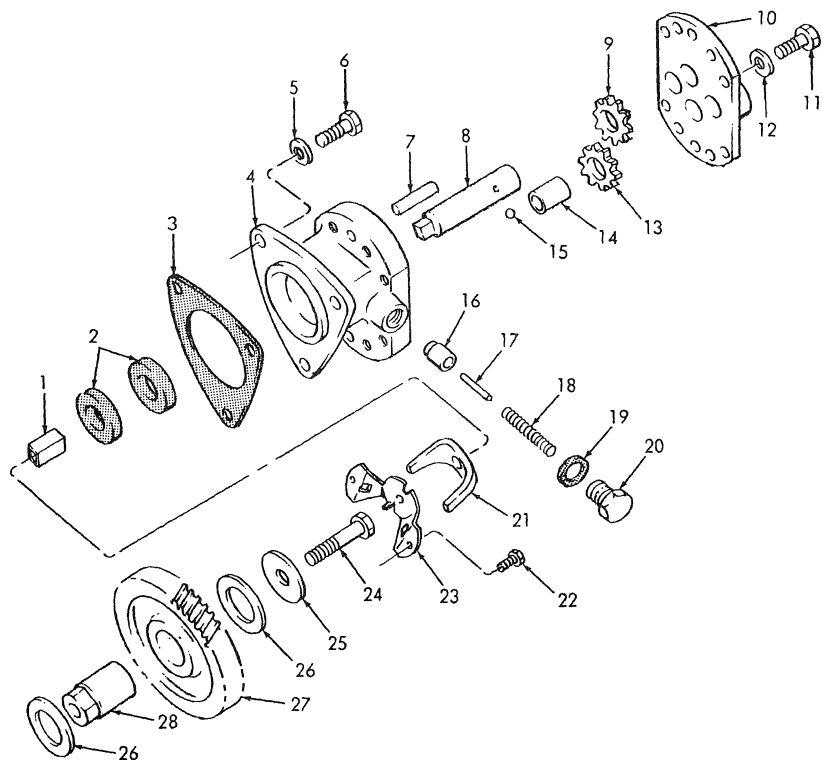
(3) Start the engine and run at 1200 r.p.m. for

one minute. The return fuel should be approximately one-half gallon.

# NOTE

If bubbles are present when the return line is immersed in fuel, it indicates a leak in the suction side of the pump.

(4) If the above conditions have been complied with and the fuel return is appreciably less than specified above, replace the fuel pump.



ME 3810-290-34/4-22

- |               |                    |            |                       |
|---------------|--------------------|------------|-----------------------|
| 1. Coupling   | 8. Shaft           | 15. Ball   | 22. Capscrew (2)      |
| 2. Seal (2)   | 9. Gear            | 16. Valve  | 23. Adapter           |
| 3. Gasket     | 10. Cover          | 17. Pin    | 24. Bolt              |
| 4. Body       | 11. Capscrew (8)   | 18. Spring | 25. Washer            |
| 5. Washer (3) | 12. Lockwasher (8) | 19. Gasket | 26. Thrust washer (2) |
| 6. Bolt (3)   | 13. Gear *         | 20. Plug   | 27. Gear              |
| 7. Pin (2)    | 14. Shaft *        | 21. Fork   | 28. Hub               |

\* Not stocked separately.

Figure 4-22. Fuel pump and drive gear assembly, exploded view.

## Section XII. EXHAUST MANIFOLDS

## 4-24. General

The air cooled exhaust manifolds are located on studs between the exhaust ports and by studs at the ends of the manifolds and secured to the cylinder head with special washers and nuts. The manifolds have a flange at the rear end, to which the flexible connection is attached.

## 4-25. Exhaust Manifolds

*a. Removal.*

(1) Loosen the clamp (6, fig. 4-23) and slide off the bossed end of the manifold (5).

(2) Loosen, but do not remove one nut (4).

(3) Remove the three remaining nuts (4) and washers (3).

(4) Support the manifold (5) and remove the remaining nut and washer.

(5) Remove the manifold and gasket (1).

*b. Cleaning, Inspection, and Repair.*

(1) Remove all rust, carbon, and oxidized material from the manifold with a wire brush.

(2) Inspect the manifold for cracks or other defects. Clean machined surfaces. Repair or replace damaged manifold.

(3) Inspect the studs (2) for damaged threads. Replace as required.

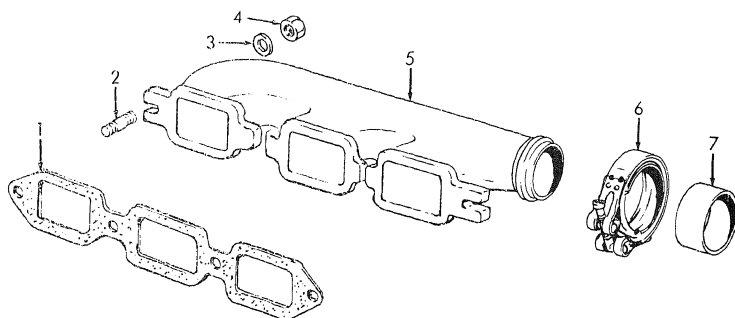
*c. Installation.*

(1) Install the exhaust manifold (5) with new gasket (1) on cylinder head. Secure with one washer (3) and nut (4) (finger tight).

(2) Install remaining washers (3) and nuts (4). Position the "dished" washers so that the crown side faces the nut.

(3) Starting with a center stud nut (4), and working alternately toward each end of the manifold, tighten the nuts securely.

(4) Slide the clamp (6) over the end of the manifold. Tighten the clamp screw firmly.



ME 3810-290-34/4-23

1. Gasket (2)
2. Stud (8)
3. Washer (8)
4. Nut (8)
5. Manifold (4)
6. Clamp assembly (2)
7. Pipe (2)

Figure 4-23. Exhaust manifold, exploded view.

## Section XIII. AIR INTAKE PIPING AND INLET HOUSING

## 4-26. General

The air inlet housing, mounted on top of the engine blower, serves as an adapter for the air intake piping. The air inlet housing contains an air shut-down valve that shuts off the air supply and stops the engine when the emergency stop button is operated. The air intake piping provides the necessary ducting between the air cleaner and the engine. The air cleaner repair is covered in TM 5-3810-290-12.

## 4-27. Air Intake Piping

## a. Removal.

(1) Loosen clamp (8, fig. 4-24) and slide hose (9) from tube (3).

(2) Loosen four clamps (1) and slide hump hoses (2) onto tube (3) sufficiently to remove from unit. Slide hump hoses and clamps from tube.

(3) Remove eight capscrews (5) and lockwashers (6). Lift manifold (4) from air inlet housing and discard gasket (7).

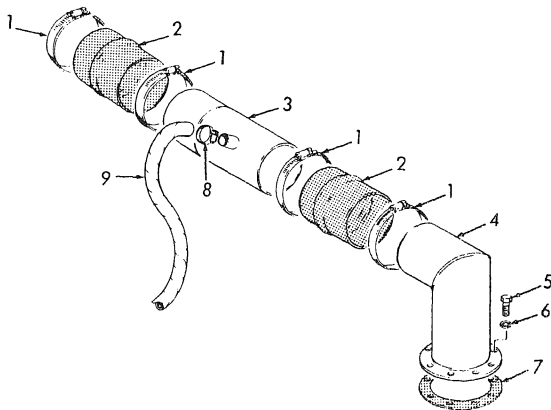
## b. Cleaning, Inspection, and Repair.

(1) Clean hump hoses with a damp cloth and dry. Inspect for cracks or cuts, replace as required.

(2) Clean all other parts with an approved cleaning solvent and dry thoroughly.

(3) Inspect tube (3) and manifold (4) for broken welds, cracks, or other damage. Repair broken welds and cracks by welding as necessary. Ends of tube and manifold must be smooth and even to insure tight seal of hump hoses. Face of manifold flange must be smooth and flat to seal with gasket (7).

c. Installation. Using a new gasket and hump hoses as necessary, install the air intake piping in the reverse order of removal. Tighten hose clamps (1) and (8) and capscrews (5) carefully to insure air tight connections between components.



JME 3810-290-34/4-24

1. Clamp (4)
2. Hump Hose (2)
3. Tube
4. Manifold
5. Capscrew (8)
6. Lockwasher (8)
7. Gasket
8. Clamp
9. Hose

Figure 4-24. Air intake piping, exploded view.

#### 4-28. Air Inlet Housing

##### a. Removal.

(1) Disconnect and remove air intake manifold (para 4-27).

(2) Tag and disconnect wire lead from shutdown solenoid (15, fig. 4-26).

(3) Remove bolts, lockwashers, washers, air inlet housing, and gasket from the blower housing (fig. 4-25). Discard gasket.

(4) Remove the screen (13, fig. 4-26).

##### b. Disassembly.

(1) Remove cotter pin (30, fig. 4-26) and pin (19).

(2) Remove four bolts (14), nuts (33), lockwashers (32), and solenoid (15).

(3) Remove nuts (16), washers (17), and bracket (18) from solenoid.

(4) Remove bolt (20), lockwasher (21), washer (22), latch (24) and spacer (23).

(5) Remove bolt (25), lockwasher (26) and bracket (21).

(6) Remove pin (7), washer (8), and packing (9) from valve shaft (29). Discard packing.

(7) Remove pins (10) that secure shutdown valves (12) to valve shaft (29).

(8) Note position of air shutdown valve spring (11) and valves (12). Withdraw shaft (29) from housing (1) to release spring and valves from position in housing.

(9) Remove and discard packing (9) from housing.

##### NOTE

The cam (27) and handle (28) does not require removal from the valve shaft unless worn and replacement is required.

##### c. Cleaning, Inspection, and Repair.

(1) Clean all parts with an approved cleaning solvent. Dry thoroughly with compressed air.

(2) Inspect the faces of the valves. They must be perfectly flat and free from burrs or nicks. Replace as required.

(3) Clean and inspect screen (13) for holes. Replace as required.

(4) Inspect springs for cracked coils and check tension manually. Replace as required. Inspect housing for cracks or damaged mating surfaces.

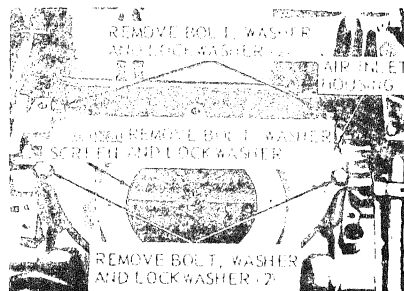
d. Assembly. Assemble air inlet housing in reverse order of disassembly. Replace all packing.

##### e. Installation.

(1) Install new gasket on top of blower housing.

(2) Mount air inlet housing on blower housing and secure with bolts, lockwashers, and washers (fig. 4-25). Torque bolts to 16-20 pound-feet.

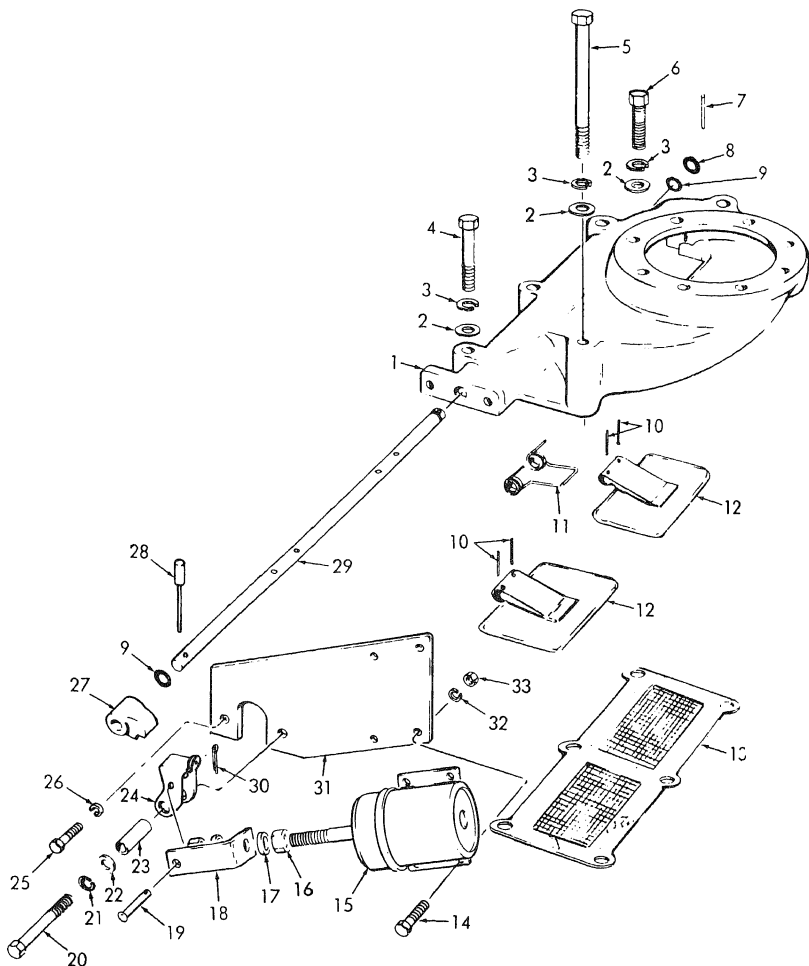
(3) Install air intake manifold (para 4-27).



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Figure 4-25. Air inlet housing, removal points.





1. Housing
2. Washer (6)
3. Lockwasher (6)
4. Bolt (3)
5. Bolt (2)
6. Bolt
7. Pin
8. Washer
9. Seal ring (2)
10. Pin
11. Spring

12. Valve
13. Screen
14. Bolt (4)
15. Solenoid
16. Nut (2)
17. Washer (2)
18. Bracket
19. Pin
20. Bolt
21. Lockwasher
22. Washer

23. Spacer
24. Latch
25. Bolt (2)
26. Lockwasher (2)
27. Cam
28. Handle
29. Shaft
30. Cotter pin
31. Bracket
32. Lockwasher (4)
33. Nut (4)

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## Section XIV. BLOWER ASSEMBLY

## 4-29. General

The blower supplies fresh air required for combustion and scavenging. Its operation is similar to that of a gear type oil pump. Two hollow double lobe rotors revolve in a housing bolted to the cylinder block. The revolving motion of the rotors provide a continuous and uniform displacement of air. The blower rotors are pinned to the steel rotor shafts. The rotor shafts are steel and the blower and plates are aluminum, providing for a compatible bearing arrangement. Gears located on the splined end of the rotor shafts assist in spacing the rotor lobes. As the lobes of the upper and lower rotors do not touch at any time, lubrication is not required. Seals are incorporated in each end of the blower rotors and serve a dual purpose; first to prevent air leakage past the blower rotor shaft bearing surfaces, and second, to prevent oil used for lubricating the blower from entering the rotor compartment.

## 4-30. Blower

## a. Removal.

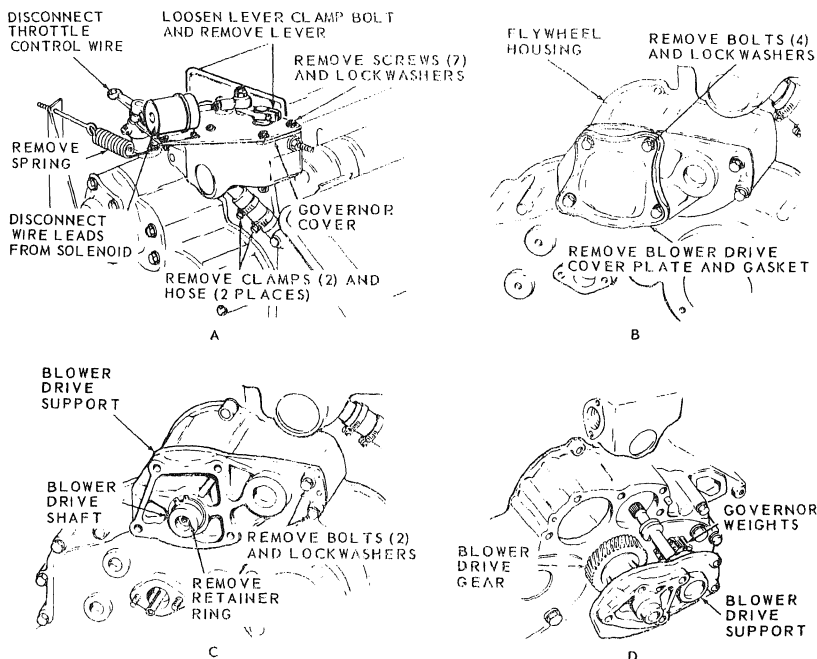
(1) The blower and governor are bolted together and must be removed as an assembly.

(2) Disconnect the linkage from the governor control levers (A, fig. 4-27).

(3) Remove the screws and lockwashers which attach the governor cover to the governor housing (A, fig. 4-27). Remove the cover and gasket from the housing.

(4) Remove two bolts (A, fig. 4-27) and lockwashers which hold the spring housing to the governor housing. Remove the spring housing and gasket.

(5) Remove the spring assembly from the governor.



(6) Loosen the hose clamps and slide the hoses back on the fuel rod covers (A, fig. 4-27).

(7) Remove the rocker cover from each cylinder head (para 4-34).

(8) Disconnect the lower fuel rod from each injector control tube lever, and also from each upper fuel rod.

(9) Remove the threaded pins (1, fig. 4-29) connecting the fuel rods to the control link lever (50). Remove the upper fuel rods.

(10) Remove the blower drive cover plate (B, fig. 4-27). Remove the retainer ring and withdraw the blower drive shaft from the housing (C, fig. 4-27).

(11) Remove the two bolts and copper washers holding the blower drive support assembly (C, fig. 4-27). Then, withdraw the assembly until the splined end of the drive shaft is free from the drive plate (D, fig. 4-27). Turn the drive assembly so the serrated end of the governor weight shaft will pass around the governor operating fork. Remove the drive support from the engine.

(12) Remove the four bolts (37, fig. 4-28) and lockwashers (38) holding the blower to the top face of the block. Lift the blower and governor assembly from the engine. Remove and discard gasket (50) and preformed packing (51).

#### NOTE

The governor is dovetailed to the blower rear end plate.

(13) Remove the six bolts and lockwashers which attach the governor housing to the blower rear end plate. Remove the governor housing (16, fig. 4-29) and gasket (48).

#### b. Disassembly.

(1) Remove the six bolts (48, fig. 4-28), special washers (49) and reinforcement plates (47) that retain the front end plate cover (46) and the front end plate (39) to the blower housing (35).

(2) Remove the end plate cover and gasket (45) from the end plate.

(3) Wedge a clean cloth between the blower rotors (29) to prevent turning. Remove four bolts (34) that hold the blower drive cam retainer (33) and blower drive spring support (19) to the rotor gear.

(4) Remove the retainer (33), support (19), and spacer (22) from the rotor gear (24).

(5) Remove four bolts (32) and governor drive plate (31) from rotor gear (23).

(6) Remove the bolts (20) and blower drive cam pilots (21) from both gears.

(7) Remove both blower gears (24 and 25) simultaneously with two gear pullers. Mark the left-hand gear to facilitate identification at assembly.

#### NOTE

Place shims (30) and spacers (25) with their respective gears to insure proper positioning at assembly.

(8) Remove three thrust plate bolts (44), spacers (40), and thrust plate (43) from the front end plate (39). Remove the bolts (42) and thrust washers (41).

(9) Tap the end plate (39) off the dowel pins (36) with a plastic hammer.

#### CAUTION

**Do not damage the mating surfaces of the end plate and housing.**

(10) Remove the rotors (29) from the blower housing (35). Remove the end plate (26) carefully as outlined in paragraph 9 above.

(11) Remove the seals (28) from each end of the rotor shafts.

(12) Disassemble the blower drive spring support (19) by driving out cam (17), thus permitting drive spring pack (18) to fall free from the drive spring support.

(13) Remove retaining ring (5) and washer (6) from hub (9). Remove assembled hub and gear from support (7).

(14) Press the drive gear (11) from hub (9) and remove key (10).

#### NOTE

Removal of governor weight shaft, which is also mounted in the blower drive support is covered in paragraph 4-32.

#### c. Cleaning, Inspection, and Repair.

(1) Clean all parts with an approved cleaning solvent. Dry thoroughly with compressed air.

(2) The finished inside face of the end plates (26 and 39) must be smooth and flat. Slight scoring may be cleaned up with a fine grit emery cloth, however, if the surface is badly scored, replace the end plate.

(3) Inspect the surfaces of the rotors (29) and blower housing (35) for burrs or scratches and remove them with an oil stone.

(4) Examine the rotor shaft serrations. Burred or peened serrations may prevent installation or block meshing with the serrations in the cam of the blower drive spring assembly.

(5) Inspect the blower gears (23 and 24). They should be replaced if there are indications of excessive wear or any damage.

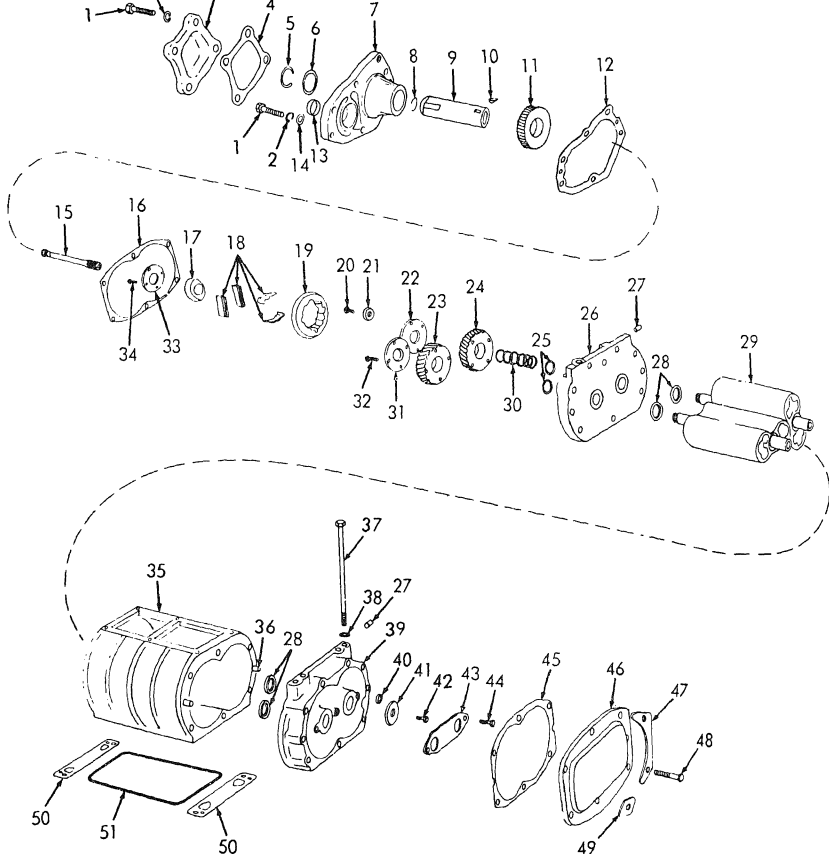
(6) Check the bearing surfaces of the rotor shafts and end plates for scoring and wear. Inspect the seals for cracks, hardness and for damage due to adherence to the shaft. When a blower is being reconditioned, the installation of new seals is recommended.

*d. Assembly.*

(1) Install governor weight shaft (para 4-32) if removed, on blower drive support.

(2) Install washer (6, fig. 4-28) and retaining ring (5) on hub (9). Lubricate hub with engine oil and install in blower drive support.

(3) Install key (10) in hub (9) and place blower drive support (gear side up) on an arbor press. Align key way of gear (11) with key (10) and press the gear onto the hub until a clearance of 0.005 inch is established between the gear and the support.



1. Bolts (6)
2. Lockwashers (6)
3. Cover
4. Gasket
5. Retaining ring
6. Washer
7. Support
8. Ring
9. Hub
10. Key
11. Gear
13. Bearing

14. Washer (2)
15. Shaft
16. Gasket
17. Cam
18. Spring Pack
19. Support
20. Bolt (2)
21. Pilot (2)
22. Spacer
23. Gear
24. Gear
25. Spacer (2)
26. Plate

27. Plug (2)
28. Seal (4)
29. Rotor (2)
30. Shims
31. Plate
32. Bolt (4)
33. Retainer
34. Bolt (4)
35. Housing
36. Pin (4)
37. Bolt (4)
38. Washer (4)
39. Plate

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40. Spacer (3)
41. Washer (2)
42. Bolt (2)
43. Plate
44. Bolt (3)
45. Gasket
46. Cover
47. Plate (2)
48. Bolt (6)
49. Plate (2)
50. Gasket (2)
51. Preformed Packing

Figure 4-28. Blower assembly, exploded view.

(4) Place the front end plate (39) on two wood blocks and install the rotors (29), gear end up, with new seals (28).

(5) Install the blower housing (35) over the rotors. Position rear end plate (26) over the rotor shafts and temporarily secure with two bolts (48).

#### NOTE

To prevent inadequate lubrication or low oil pressure, care must be exercised in the assembly of the front and rear blower end plates to the blower housing. The rear end plate does not have tapped holes for the thrust washer plate bolts and is the only cover that has the vertical oil passage drilled through into the pocket on the left side of the plate for supplying lubrication to the blower drive gear bearing.

(6) Turn the assembly over and temporarily secure the front end plate (39) with two bolts (48). Position thrust washers (41) on ends of rotor shafts and secure with two bolts (42). Tighten bolts to 54-59 pound-feet torque.

(7) Attach three spacers (40) and thrust plate (43) to the front end of the blower with three thrust plate bolts (44). Tighten the bolts to 7-9 pound-feet torque. Then check the clearance between the thrust plate and the thrust washers. The clearance should be 0.001 to 0.003 inch.

(8) Position the rotors so that the missing serrations on the gear end of the rotor shafts are 90° apart. Install the shims (30) and spacers (25) in the counterbore in the rear face of the rotor gears (23 and 24). Place the gears on the ends of the shafts with the missing serrations in alignment with the missing serrations on the shafts.

(9) Tap the gears lightly with a soft hammer to seat the gears on the shafts. Then, rotate the gears until the punch marks on the face of the gears match. If the punch marks do not match, reposition the gears.

(10) Wedge a clean cloth between the blower rotors. Use the blower rotor gear retaining bolts and plain washers to press the gears on the rotor shafts. Turn the bolts uniformly until the gears are tight against the shoulder on the shafts.

(11) Remove the gear bolts and plain washers. Place the pilot (21) in the counterbore of the gears and start the twelve point bolt (20) in the righthand rotor shaft and start the hex head bolt (20) in the left-hand rotor shaft. Tighten the bolts to 25-30 pound-feet torque.

(12) Check the backlash between the blower gears. The backlash should be 0.0005 to 0.0025 inch with new gears. Replace the gears if the backlash exceeds 0.0035 inch.

(13) After the blower rotors and gears have been installed, the blower rotors must be timed.

The rotors, when properly positioned run with a slight clearance between the rotor lobes and with a slight clearance between the lobes and the walls of the housing. The clearances between the rotors may be established by moving one of the helical gears out or in on the shaft relative to the other gear. Moving the gears OUT or IN on the rotors is accomplished by adding or removing shims between the gear hub and the rotor spacers. Refer to table 4-2.

(14) Measurements should be taken across the entire length of each rotor lobe to be certain that a minimum clearance of 0.004 inch exists at the air outlet side of all blowers; and a minimum clearance of 0.010 inch exists at the air inlet side. Similarly, the clearance between rotor lobes should be measured across the length of the lobes. By rotating the gears, position the lobes so that they are at their closest relative position.

#### NOTE

Push and hold the rotor toward the front end plate when the clearance is being checked and toward the rear when the rear end plate-to-rotor clearance is being taken.

Table 4-2. Blower Rotor Clearances

| Rotor Position      | Minimum-Inches |
|---------------------|----------------|
| Rotor to housing    |                |
| Inlet side          | 0.010          |
| Outlet side         | 0.004          |
| Between rotor lobes | 0.010          |
| Rotor to end plate  |                |
| Front               | 0.008          |
| Rear                | 0.012          |

(15) Assemble the blower drive spring support assembly by:

(a) Place the drive spring support (19) on two blocks of wood.

(b) Position the drive spring seats (18) in the support.

(c) Apply grease to the springs to hold the leaves together, then slide the two springs (consisting of 15 leaves per pack) into the drive spring seats.

(d) Place the blower drive cam (17) over the end of installing tool. Insert the tool between the springs, and press the cam into place between the springs.

(16) Install the drive spring support assembly with spacer (22) on the rotor gear (24) at the rear end of the blower.

#### NOTE

The coupling is placed on the left-hand gear on the

blower. A spacer is placed between the gear and coupling.

(17) Secure the cam retainer plate (33) to the support (19) with four bolts (34) and tighten them to 8-10 pound-feet torque.

(18) Install the governor drive plate (31) on the right-hand rotor gear (23) with four bolts (32) and tighten them to 8-10 pound feet torque.

(19) Secure the rear end plate cover (26) to governor with six bolts and special washers. Tighten the bolts to 20-25 pound-feet torque.

*e. Installation.* After securing the governor to the blower, install the blower on the engine as follows:

(1) Install the blower-to-block gaskets (50) and preformed packing (51).

(2) Install the blower and governor assembly on the engine.

#### NOTE

Since the governor is dovetailed to the cylinder block rear end plate, the governor end of the blower must be in position before the blower can be lowered onto the engine.

(3) Secure the blower to the block with four bolts (37) and flat washers (38). Tighten the bolts to 10-15 pound-feet torque.

(4) Install the blower drive support as follows:

(a) Affix a new gasket (12) to the blower drive support (7).

(b) Position the speed-limiting weights in a horizontal position to provide clearance. Turn the operating shaft fork away from the blower, if necessary, for additional clearance.

(c) Move the blower drive assembly into the openings in the flywheel housing until the blower drive gear enters the housing (D, fig. 4-27). Then, turn the drive assembly slightly so that the serrated end of the governor weight shaft may pass around

behind the governor operating fork, permitting the fork to slip into place between the serrated end and the riser bearing.

(d) Then push the drive support assembly up against the flywheel housing; the serrations in the governor weight shaft and in the governor drive plate on the blower timing gear must mesh. The blower drive gear must also mesh with the mating gear.

(5) Secure the small end of the blower drive support to the flywheel housing with two bolts (11) and copper washers (14). Tighten the bolts to 20-25 pound-feet torque.

(6) Insert the blower drive shaft (15) into the blower drive gear hub (9). If necessary, turn the crankshaft so that the serrations on the blower drive shaft register with the serrations in the blower drive cam and the blower drive gear hub.

(7) Install the retainer (8) in the blower drive gear hub to secure the blower drive shaft.

(8) Attach a new gasket (4) to the blower drive support cover (3); then secure the cover to the support with bolts (11) and lockwashers (2). Tighten the bolts to 20-25 pound-feet torque.

(9) Tighten the blower-to-block bolts (37) 55-60 pound-feet torque.

(10) Insert the upper fuel rods through the fuel rod covers and attach the rods to the governor control link lever.

(11) Attach the lower fuel rods to the injector control tube levers and upper fuel rods.

(12) Slide the fuel rod cover hoses in place and secure them with hose clamps. (A, fig. 4-27).

(13) Install the variable speed spring assembly in the governor (para 4-32).

## Section XV. VARIABLE SPEED GOVERNOR

### 4-31. General

The variable speed mechanical governor is mounted between the engine blower and flywheel housing. A cover and lever assembly, control housing, spring housing, and weight and shaft assembly comprise the basic parts of the governor. One end of the weight shaft is splined to a drive plate attached to the driven blower gear to provide a means of driving the governor. The other end of the weight shaft is supported by a bearing in the blower drive support. The governor housing serves as the rear end cover of the blower housing which explains the reason for removing the blower and governor as an assembly (para 4-30).

### 4-32. Variable Speed Governor

*a. Removal.* Remove the governor as instructed in paragraph 4-30.

*b. Disassembly.*

(1) Remove the retaining ring (25, fig. 4-29) and the two seal retaining washers (26). Withdraw the throttle shaft assembly (37) from the cover (17).

(2) Remove the packing (27) from the cover.

(3) Wash the cover assembly thoroughly in an approved cleaning solvent and inspect the bushing for wear or damage. If the bushing is satisfactory for further use, removal is unnecessary.

(4) If the bushing is to be removed, place the governor cover with the inner face down on an arbor press. Place a hollow spacer between the cover and the bed of the press. Place the bearing remover on top of the bushing and press out of the cover.

NOTE

Bushing is replaced by two bearings (23).

(5) Loosen the clamp bolt (9, fig. 4-30) and remove the speed control lever (7) from the shaft (33) of the variable speed spring housing. Remove the key (10).

(6) Loosen the clamp bolt (29) and remove the booster spring lever (31). Remove the key (10).

(7) Remove the plain washer (6) and packing (5).

(8) Remove the pipe plug (36) from the housing and, working through the opening, remove the setscrew (12) from the spring lever (11).

(9) Support the spring housing in an arbor

press. Use a brass rod to press the shaft (33), and bearing (4) from the housing.

(10) Remove the spring lever assembly (11).

(11) Press the second bearing (4) from the housing.

(12) Remove the governor adjusting screw (15, fig. 4-29).

(13) Remove the retainer (2) and washer (3) from the control link lever pin and withdraw the control link lever (50) and washer (3).

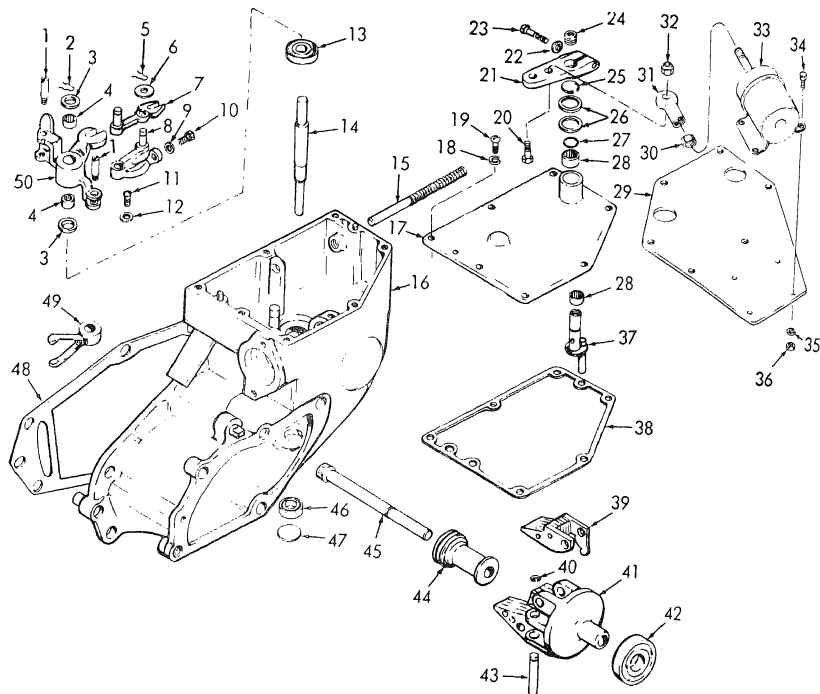
(14) Support the control link lever (50) on a spacer and place them on the bed of an arbor press. Then press both bearings (4) from the lever.

(15) Remove the retainer (5) and washer (6) from the pin in the operating shaft lever (8) and remove the differential lever (7).

(16) remove the plug (47) at the bottom of the governor housing.

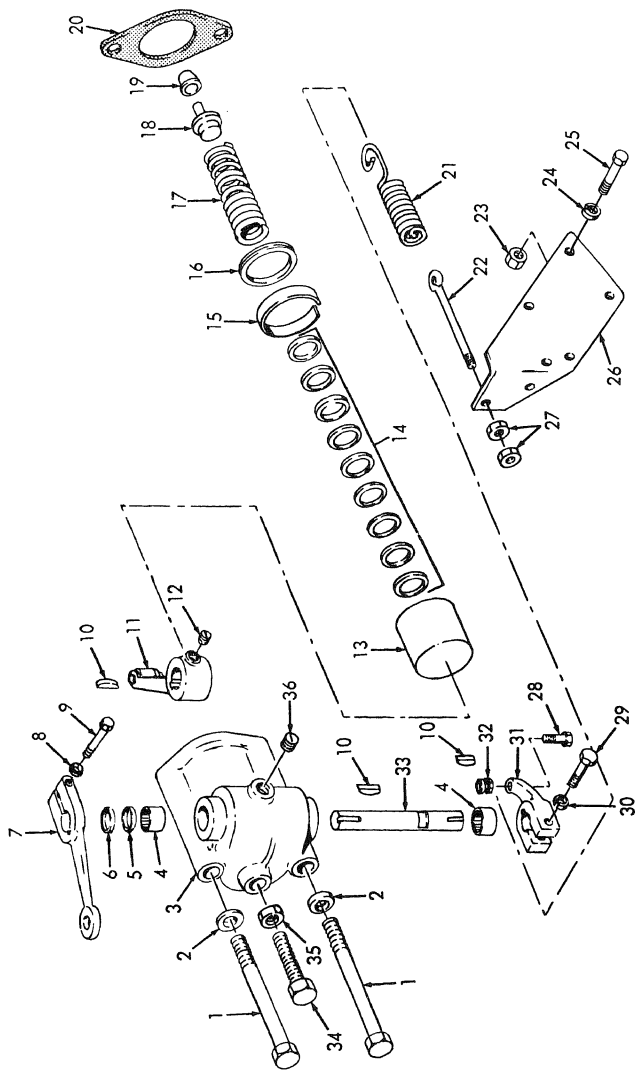
(17) Remove the operating shaft upper bearing retaining screw and washer (11 and 12).





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- |                     |                        |
|---------------------|------------------------|
| 1. Pin (2)          | 26. Washer (2)         |
| 2. Retainer         | 27. Packing            |
| 3. Washer (2)       | 28. Bearing (2)        |
| 4. Bearing (2)      | 29. Bracket            |
| 5. Retainer         | 30. Nut                |
| 6. Washer           | 31. Rod end            |
| 7. Lever            | 32. Lock nut           |
| 8. Lever            | 33. Solenoid           |
| 9. Nut              | 34. Capscrew           |
| 10. Capscrew        | 35. Lockwasher         |
| 11. Screw           | 36. Nut                |
| 12. Lockwasher      | 37. Shaft              |
| 13. Bearing         | 38. Gasket             |
| 14. Shaft           | 39. Weight (2)         |
| 15. Adjusting screw | 40. Retaining ring (2) |
| 16. Housing         | 41. Carrier            |
| 17. Cover           | 42. Bearing            |
| 18. Lockwasher      | 43. Pin (2)            |
| 19. Screw           | 44. Riser              |
| 20. Capscrew        | 45. Shaft              |
| 21. Lever           | 46. Bearing            |
| 22. Lockwasher      | 47. Expansion plug     |
| 23. Capscrew        | 48. Gasket             |
| 24. Plug            | 49. Fork               |
| 25. Retaining ring  | 50. Lever              |



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Figure 4-30. Variable speed governor spring housing assembly, exploded view.

## Key to figure 4-30.

1. Bolt (2)
2. Washer (2)
3. Housing
4. Bearing (2)
5. Packing (2)
6. Washer
7. Lever
8. Washer
9. Bolt
10. Key (3)
11. Lever
12. Setscrew
13. Spring retainer
14. Shims
15. Stop
16. Stop
17. Spring
18. Plunger
19. Plunger guide
20. Gasket
21. Spring
22. Eye bolt
23. Nut
24. Washer
25. Bolt
26. Bracket
27. Nut (2)
28. Bolt
29. Bolt
30. Washer
31. Lever
32. Nut
33. Shaft
34. Idle screw
35. Nut
36. Plug

(18) Remove the operating shaft lower bearing (46) by placing the inverted governor housing on the bed of an arbor press; use wood block(s) to prevent damage to the dowel pins in the housing. Press on the shaft, using a rod small enough to pass through the bearing, until the bearing is free of the shaft. Then, withdraw the bearing.

(19) Place an end wrench between the operating fork (49) and the governor housing; also place a rod on the end of the operating shaft (14) and press the shaft out of the fork.

(20) Withdraw the operating shaft, operating shaft lever, and bearings.

(21) Press the upper bearing (13) and operating shaft lever (8) from the shaft.

(22) Remove the retainers (40) from the governor weight pins (43). Then, drive the pins out of the carrier and the weights. Remove the governor weights (39).

(23) Press the governor weight carrier (41) from the shaft (45).

(24) Slide the governor riser and bearing

assembly (44) from the shaft. *Do not remove the bearing since the bearing and riser are serviced only as an assembly.*

(25) Tap the governor weight shaft bearing (42) from the blower drive support. If the bearing is a tight fit, drive the plug from the support, and using a spacer against the outer race of the bearing, press or tap the bearing from the support.

*c. Cleaning, Inspection, and Repair.*

(1) Clean all of the parts with an approved cleaning solvent and dry them with compressed air.

(2) Inspect all bearings. Replace corroded or pitted bearings. Revolve ball bearings slowly by hand. Replace bearings which indicate rough or tight spots.

(3) Examine the riser thrust bearing for excessive wear, flat spots, or corrosion. If any of these conditions exist, install a new riser and thrust bearing assembly.

(4) Inspect the control link lever, needle bearings and control link lever pin for wear. Replace worn parts. If a new control link lever pin is required, remove the old pin and press the new pin in the governor housing; the pin must project 1.055 to 1.060 inches above the boss in the housing.

(5) Examine the governor weight carrier pins for wear.

(6) Inspect the governor spring, spring retainer, plunger, plunger guide, adjusting screws and other parts of the governor housing for wear.

(7) Check the serrations on the governor weight shaft and the drive plate on the blower timing gear for wear. Replace worn parts.

*d. Assembly.*

(1) Place the cover (17, fig. 4-29) with the inner face down, on the bed of an arbor press. Start a needle bearing (28) straight into the bearing bore of the cover, with the number side of the bearing up. Then press the bearing in until the shoulder on the installing tool contacts the cover.

(2) Turn the cover over and start the second bearing (28), number side up, in the bearing bore. Place a flat washer over the pilot end of tool and insert the tool in the bearing. Press the bearing in until the washer contacts the cover.

**NOTE**

The bushing used in the cover is not serviced. For service, install two small needle bearings. Do not use impact tools to install needle bearings.

(3) Pack the needle bearings with grease. Then, slide the governor throttle shaft (37, fig. 4-29) through the bearings, with the fulcrum lever pin seated in the slot on the underside of the cover.

(4) Install new packing (27) on top of the

upper bearing. Then install two retaining washers (26) and lock them in place with the retainer (25).

(5) Lubricate the needle bearings (4, fig. 4-30) with grease. Support the variable speed spring housing (3) on an arbor press and start one bearing, number side up on the housing. Press the bearing in: the housing. When the shoulder on the tool contacts the housing, the bearing will be properly positioned.

#### NOTE

Do not use impact tools to install needle bearings.

(6) Lubricate the spring lever (11) with engine oil and insert the lever in the housing. Install a key (10) and slide the shaft (33) through the lever and through the needle bearing in the housing.

(7) Place the second needle bearing, number side up, over the shaft. Press the bearing in until the shoulder on the installing tool contacts the housing.

(8) Thread the setscrew (12) in the lever (11) and tighten it to 12-ft-lbs. torque. Stake the lever or lock the screw in place. Install the pipe plug (36).

(9) Install packing (5) and washer (6) at the eed control lever end of the shaft.

(10) Install a key and place the speed control ever (7) on the shaft. Secure the lever with a bolt (9) and lockwasher (8).

(11) Install a key (10) and the booster spring lever (31) on the shaft (33). Secure with bolt (29) and lockwasher (30).

(12) Assemble the governor housing by starting the upper operating shaft bearing (13, fig. 4-29) number side up, on the end of the shaft (14). Support the lower end of the shaft on an arbor press. Place a sleeve on the inner race and press the bearing against the shoulder on the shaft.

(13) Start the operating shaft lever (8), with the pivot pin, on the end of the shaft (14) with the flat on the shaft registering with the flat in the lever bore. Use a sleeve to press the lever tight against the bearing.

(14) Insert the lever and shaft assembly through the top of the governor housing. Position the operating fork (49) over the lower end of the shaft, with the finished cam surfaces facing toward the rear of the governor (toward the governor drive).

(15) Support the operating shaft and governor housing on the bed of an arbor press with the upper end of the shaft resting on a steel block. Align the flat in the fork with the flat on the shaft, then place a sleeve over the shaft and against the fork. Press the fork tight against the shoulder on the shaft.

(16) Start the lower operating shaft bearing (46), number side up, on the end of the shaft. Place

a sleeve on the inner race and press the bearing against the shoulder on the shaft.

(17) Start the lower operating shaft bearing (46), number side up, on the end of the shaft. Place a sleeve on the inner race and press the bearing against the shoulder in the housing.

(18) Lubricate both bearings with engine oil.

(19) Apply a good quality sealant around the edge of a new expansion plug (38) and tap it in place in the housing.

(20) Place the differential lever (7) over the pivot pin in the operating shaft lever (8). Secure the lever with a washer (6) and retainer (5).

(21) If previously removed, install the gap adjusting screw (10) and locknut (9) in the tappet hole in the operating shaft lever (8).

(22) Support the control link lever (50) on a steel spacer. Start one bearing (4), number side up, in the lever. Insert the pilot end of the installing tool in the bearing, and press the bearing in the lever. Reverse the lever and install the second bearing (4) in the same manner.

(23) Place a washer (3) over the end of the control link lever pin in the governor housing. Place the needle bearings with grease and place the lever (50), with the tapped ends of the link pin holes down, over the pin in the housing. Secure the lever with a washer (3) and retainer (2).

(24) Install the adjusting screw (15), leaving approximately  $\frac{3}{4}$  inch of the screw extending from the governor housing.

(25) Lubricate the governor weight shaft (45) with engine oil, then slide the riser assembly (44) over the shaft with the bearing end toward the serrated end of the shaft. Pack the bearing with grease.

(26) Press the shaft into the weight carrier (41). The installing tool will properly position the weight carrier on the shaft.

(27) Position the weights (39) on the carrier and drive the weight pins (43) in place. Install the retaining rings (40).

(28) Place the blower drive support (D, fig. 4-27) with the inner face up, on the bed of an arbor press. Start the governor weight shaft bearing (42, fig. 4-29) number side up, in the bearing bore of the support. Place a sleeve against the outer race and press the bearing firmly against the shoulder in the bearing bore.

(29) Place a support under the inner race of the bearing in the blower drive support and start the weight end of the governor weight shaft into the bearing. Press the shaft in until the shoulder on the shaft contacts the inner race of the bearing. Press the shaft in straight to avoid brinelling the bearing.

### e. Installation.

(1) Attach a new gasket (48, fig. 4-29) to the governor housing and place the housing against the blower rear end plate. Secure the governor housing to the blower with six bolts and lockwashers.

(2) Install the blower and governor assembly on the engine as outlined in paragraph 4-30.

(3) Assemble and install the variable speed spring and housing on the governor as follows:

(a) Install the spring plunger guide (19, fig. 4-30) in the governor housing (16, fig. 4-29).

(b) Insert the spring plunger (18, fig. 4-30) in the plunger guide.

(c) Insert the solid stop (16) in the governor housing.

(d) Place the spring retainer (13) in the spring housing with the closed end of the retainer against the spring lever (11). If shims (14) were used, place them inside the spring retainer. Insert the split stop (15) in the spring housing and against the spring retainer.

(e) Insert the variable speed spring (17) in the spring retainer with the tightly wound end of the spring against the shims.

(f) Insert two bolts (1) with lockwashers (2) through the spring housing (3) and place a new gasket (20) over the bolts and against the housing.

(g) Place the spring housing in position against the governor housing, with the spring plunger engaged in the end of the spring. Thread the bolts into the governor housing and tighten them.

(h) Install the idle speed adjusting screw (34) and locknut (35) if removed.

(4) Place a new gasket (38, fig. 4-29) on the governor, then install the governor and lever assembly. Be sure the governor control lever shaft (37) enters the slot in the differential lever (7). Position the solenoid mounting plate (29) on the cover (17) and secure to the governor with seven screws (19), and lockwashers (18).

## Section XVI. ROCKER ARM COVERS AND CYLINDER HEADS

### 4-33. General

a. The rocker arm covers are steel stampings, which provide protection for the valve and injector operating mechanisms. The right cover is equipped with an adapter outlet to which is attached the crankcase breather hose. The left cover is equipped with an oil filler cap.

b. The cylinder head is a one-piece casting. Located in the cylinder head are the exhaust valves, fuel injectors, rocker arms, and cam followers. Exhaust valve inserts, pressed into the head, permit accurate seating of the valves under varying conditions of temperature. To ensure efficient cooling, the exhaust passages, valve inserts and injector tubes are completely surrounded by water. In addition, cooling of these areas is further assisted by the use of double jet spray nozzles installed between each pair of cylinders in the water inlet ports. Nozzle holes are so positioned that the comparatively cool water which enters the head is directed at high velocity against the sections of the head which are subjected to the greatest heat. To seal compression between the cylinder head and the block, separate laminated metal gaskets are provided at each cylinder. Water and oil passages between the block and head are sealed with synthetic rubber seal rings.

### 4-34. Rocker Arm Covers

#### a. Removal.

(1) Loosen hose clamp and slide breather hose from adapter on right hand rocker arm cover.

(2) Remove each cover by removing four screws (3, fig. 4-32), cover (2), and gasket (4). Discard gasket.

#### b. Cleaning, Inspection and Repair.

(1) Clean all parts with an approved cleaning solvent and dry thoroughly.

(2) Inspect covers for cracks, dents, or other damage. Replace covers as required.

(3) Remove cap assembly (1, fig. 4-32) and inspect for damage. Replace as required.

c. Installation. Install the rocker arm covers in the reverse order of removal, using new gaskets (4).

#### NOTE

The cover with the oil fill cap must go on the left cylinder head.

### 4-35. Cylinder Head

#### a. Removal.

#### NOTE

The instructions for removal and repair of the right and the left cylinder head assemblies are the same, since the assemblies are basically identical.

(1) Disconnect and remove fuel lines (para 4-22).

(2) Remove thermostat housing, cross-over tube, and elbows (refer to TM 5-3810-290-12).

(3) Remove exhaust manifolds (para 4-25).

(4) Remove air intake piping (para 4-27) and air inlet housing (para 4-28).

(5) Remove blower and governor assemblies (para 4-30).

(6) Remove rocker arm covers (para 4-34).

(7) Remove injector control tube (para 4-39).

(8) Remove fuel injectors (para 4-40).

(9) Attach a suitable lifting sling to the cylinder head (fig. 4-31) and remove eight bolts (16, fig. 4-32).

(10) Remove cylinder head, cylinder head seal strip, oil hole seal rings, water hole seal rings, and the three cylinder liner compartment gaskets (fig. 4-31). Support the cylinder on work table with wood blocks at least 2 inches thick.

*b. Disassembly.*

(1) Remove the rocker arms (para 4-37).

(2) Remove valve springs, push rods, cam followers and valves (para 4-37 and 4-38).

(3) Remove studs (10, fig. 4-32), plugs (9, 13, 14, and 15), and adapter (12).

(4) Remove bolts (5), lock washers (6), cover (7) and gasket (8). Discard the gasket.

(5) Remove injector tubes (21) and ring (20). Discard the rings.

**NOTE**

A cylinder head gasket set containing all gaskets required for the overhaul of one cylinder head is available.

*c. Cleaning, Inspection, and Repair.*

(1) Clean cylinder head with an approved cleaning solvent. Use probes and brushes to clean fuel passages. If water passages are coated heavily with scale, remove water nozzles, and thoroughly clean water jacket areas.

(2) Check cylinder casting for leaks by sealing off water holes with suitable clamps and rubber gaskets held in place by bolts. Immerse casting in a water tank previously heated to 180° — 200° F. Apply 80-100 pounds per square inch air pressure to water jacket and watch for bubbles which indicate cracks and leaks in casting. Dry head with compressed air.

(3) Inspect bottom surface of casting for warpage by using a straight edge and feeler gage at points illustrated in figure 4-33A. Maximum allowable warpage is 0.005 inch longitudinal and 0.004 inch transverse. Replace the head if warpage exceeds limits specified, or if head is cracked. *Do not attempt to repair the head.*

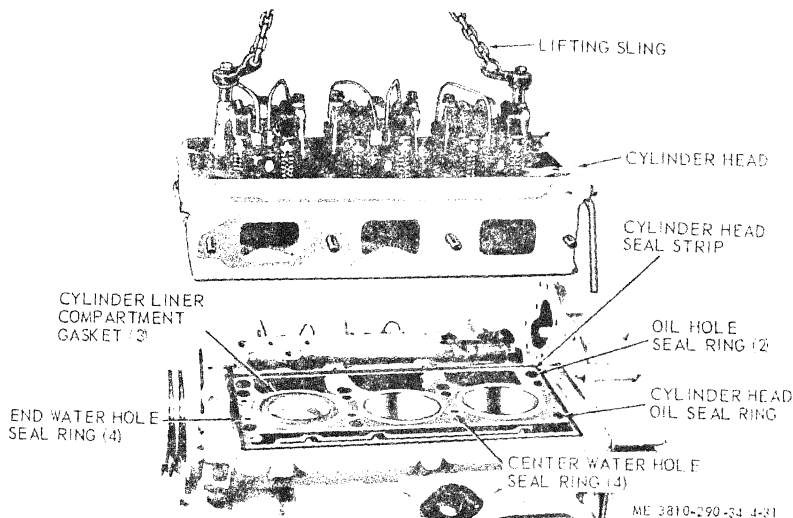
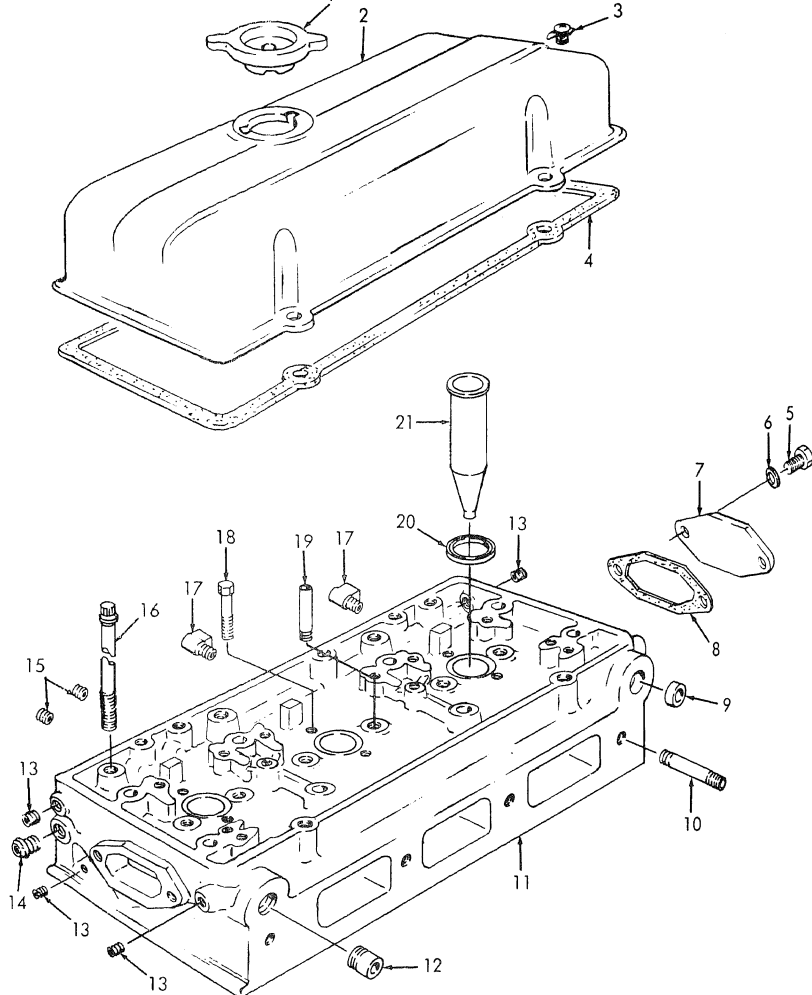


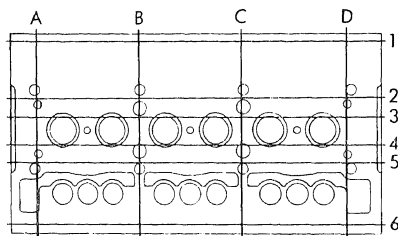
Figure 4-31. Removing cylinder head, gaskets, and seal rings.



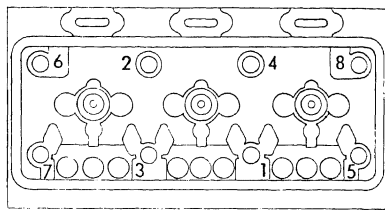
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- |                       |                   |              |                |
|-----------------------|-------------------|--------------|----------------|
| 1. Cap Assembly       | 7. Cover          | 12. Adapter  | 17. Elbow (2)  |
| 2. Cover              | 8. Gasket         | 13. Plug (4) | 18. Bolt (3)   |
| 3. Screw Assembly (4) | 9. Plug (3)       | 14. Plug (2) | 19. Guide (12) |
| 4. Gasket             | 10. Stud (4)      | 15. Plug (2) | 20. Ring (3)   |
| 5. Bolt (2)           | 11. Head Assembly | 16. Bolt (8) | 21. Tube (3)   |
| 6. Lockwasher (2)     |                   |              |                |

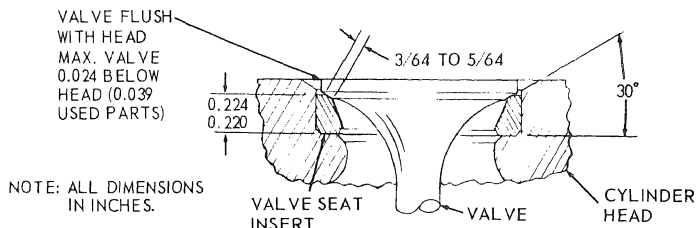
Figure 4-32. Rocker cover and cylinder head, exploded view.



A. HEAD FLATNESS CHECK POINTS.



B. CYLINDER HEAD TIGHTENING SEQUENCE.



NOTE: ALL DIMENSIONS  
IN INCHES.

C. EXHAUST VALVE & INSERT POSITIONING

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Figure 4-33. Cylinder head warpage inspection, bolt tightening sequence, and valve positioning details.

(4) Replace loose or corroded water nozzles. Clean the water port holes with a  $\frac{5}{16}$  inch diameter drill. Flare edges of holes slightly. If holes in head have been enlarged by corrosion, expand nozzles with suitable tool to assure tight fit. Nozzles must be flush or recessed  $1/32$  inch below surface to head.

(5) Inspect the valve guides (19, fig. 4-32) for scoring and wear. If valve stem-to-guide clearance exceeds 0.005 inch, replace the guides.

(a) Support the cylinder head, bottom side up, on 4-inch wooden blocks on work bench.

(b) Drive valve guide out from bottom of cylinder head with suitable remover.

(c) Turn cylinder head right side up. Insert threaded end of new guide in valve guide replacer tool. Position valve guide squarely in cylinder and gently tap installing tool contacts bottom of counterbore in cylinder head.

#### CAUTION

Use correct replacer to avoid damaging valve guide and to assure proper location of guide in head.

(6) Inspect the valve seat inserts for cracks or burning. Replace as necessary using the following procedures:

(a) Place cylinder head on side of a bench.

(b) Place collet of remover inside valve seat insert so bottom of collet is flush with bottom of insert.

(c) Hold collet handle and turn "T" handle to expand collet cone until insert is held secured by remover.

(d) Tap drive bar once or twice to move insert about  $1/16$  inch away from its seat in cylinder head.

(e) Loosen collet cone and move remover into insert slightly so narrow flange at bottom of collet is below valve seat insert.

(f) Tighten collet cone and continue to drive insert out of cylinder head.

(g) Inspect counterbores for cleanliness, concentricity, flatness and cracks. Valve insert counterbores in cylinder head have a diameter of 1.159 inch to 1.160 inches, and a depth of 0.298 to 0.302 inch.



(h) Immerse cylinder head for at least 30 minutes in water heated to 180° to 200° F. Preheating cylinder head will expand counterbores.

(i) Rest cylinder head, bottom side up, on work bench and locate insert squarely in counterbore, setting face up. Install insert in cylinder head while head is still hot and insert is at room temperature. Otherwise installation will be difficult and parts may be damaged.

(j) Drive insert in place with replacer, until it seats solidly in cylinder head.

(k) Grind valve seat insert and check it for concentricity in relation to valve guide as outlined below:

(7) When a new valve seat insert is installed, or an old insert is reconditioned, work must be done as follows:

#### CAUTION

**Do not permit grinding wheel to contact cylinder head when grinding inserts.**

(a) Apply a 30-degree grinding wheel to valve seat insert.

(b) Use a 60-degree grinding wheel to open throat of insert.

(c) Grind top surface of insert with 15-degree wheel to narrow width of seat to specified  $3/64$  to  $5/54$  inch. 30 degree insert face may be adjusted, relative to center of valve face with 15 to 60 degree grinding wheels.

(8) Maximum amount exhaust valve may protrude beyond cylinder head (when valve is in closed position) and still maintain proper piston-to-valve clearance is shown in figure 4-33C. Grinding will reduce thickness of valve seat insert and cause valve to recede into cylinder head. If, after several grinding operations, valve recedes beyond limits, replace valve seat insert.

(9) After grinding has been completed, clean valve seat insert thoroughly and dry it with compressed air. Set a dial indicator in position, and rotate to determine concentricity of each valve seat insert relative to valve guide. Total runout must not exceed 0.002 inch. If a runout of more than 0.002 inch is indicated, check for a bent valve guide before regrinding insert.

(10) When a valve seat insert runout within the desired limits is obtained, apply a light coat of Prussian blue, or similar paste, to the valve seat insert. Lower the stem of the valve in the valve guide and bounce, do not rotate, the valve on the insert. The most desirable area of contact is at the center of the valve face.

(11) Replace fuel injector tubes found defective during inspection as follows:

(a) Place suitable tool in fuel injector tube.

(b) Loosen fuel injector tube with a

hammer, and withdraw injector tube and packing from cylinder head.

(c) Place new ring (20, fig. 4-32) in cylinder head fuel injector tube counterbore.

(d) Place suitable drive and pilot in fuel injector tube.

(e) Slip injector tube (21) into injector bore and drive into place. Flange at upper end of tube will seat on packing injector tube counterbore of cylinder head when injector tube is properly positioned.

(f) With fuel injector tube properly positioned in cylinder head, upset (flare) lower end of injector tube. Turn cylinder head bottom side up. Remove pilot and thread an upsetting die into tapped end of installer tools.

(g) Using a socket and a torque wrench, apply approximately 30 pound-feet on upsetting die.

(h) Remove fuel injector tube installing tool.

(i) Place a few drops of light cutting oil flutes of a reamer and carefully position reamer fuel injector tube.

(j) Turn reamer in a clockwise direction (withdrawing reamer frequently for removal of chips) until lower shoulder of reamer contacts fuel injector tube. Clean out all chips.

(k) With cylinder head bottom side up, remove excess stock by inserting pilot of suitable cutting tool into small hole in fuel injector tube. Use a socket and speed handle and remove excess stock until lower end of fuel injector tube is from flush to 0.005 inch below finished surface of cylinder head. With first reaming operation completed and injector tube spotfaced, wash interior of injector tube with mineral spirits paint thinner or dry-cleaning solvent, and dry with compressed air. Perform second reaming operation as directed in the following steps:

#### NOTE

Tapered lower end of fuel injector tube must provide a smooth and true seat for lower end of fuel injector nut. To determine amount of stock that must be reamed from bevel seat of tube, fuel injector assembly should be installed in tube and relationship between numbered surface of spray tip to fire deck of cylinder head noted.

#### CAUTION

Replacement injector tubes are semi-finished and have a narrow land machined at the beveled seat to reduce reaming time. Exercise extreme care while reaming to prevent cutting too deeply and possibly through the thin wall of the tube.

(l) Place a few drops of cutting oil on bevel seat to tube. Carefully lower reamer into fuel injector tube until it contacts bevel seat.

(m) Make a trial cut by turning reamer steadily and apply slight downward force on reamer. Remove reamer, blow out chips, and look at bevel seat to see what portion of seat has been cut.

(n) Proceed carefully with reaming operation, withdrawing reamer occasionally to observe reaming progress.

(o) Remove chips from fuel injector tube and using an injector as a gage, continue reaming operation until shoulder of spray tip is from flush to 0.015 inch below fire deck of cylinder head.

#### d. Assembly.

(1) Install the plugs (9, 13, 14 and 15, fig. 4-32) studs (10), and miscellaneous fittings removed during disassembly.

(2) Install valves and associated components (para 4-38 and 4-37).

(3) Install rocker arm assemblies (para 4-37).

(4) Position cover (7, fig. 4-32) with new gasket (8) and secure with bolts (5) and lockwashers (6).

#### e. Installation.

(1) Position new compartment gaskets, water seal rings, oil seal rings, and cylinder head seal strip in cylinder block counterbores (fig. 4-31).

(2) Install two cylinder head guides studs in cylinder block and position cylinder head over pilot guide studs and against cylinder block using suitable sling.

### CAUTION

**Do not dislocate position of compartment gaskets or seal rings while cylinder head is being lowered into place.**

(3) Lubricate mounting bolts (16, fig. 4-32) with clean OE-10 engine oil and position in cylinder head (11). Remove guide studs.

(4) Tighten bolts gradually and uniformly using numbered sequence (fig. 4-38). Tighten bolts to 170-180 pound-feet torque.

(5) Install fuel injectors (para 4-40) and injector control tube (para 4-39).

(6) Install rocker arm covers (para 4-34).

(7) Install blower and governor assemblies (para 4-30).

(8) Install air inlet housing (para 4-28) and air intake piping (para 4-27).

(9) Install exhaust manifolds (para 4-25).

(10) Install water manifolds (Refer to TM 5-3810-290-12).

(11) Install fuel lines (para 4-22).

## Section XVII. ROCKER ARMS, PUSH RODS, CAM FOLLOWERS, VALVES AND VALVE SPRINGS

### 4-36. General

#### a. Rocker Arms, Push Rods and Cam Followers.

Three rocker arms are provided for each cylinder; the two outer arms operate the exhaust valves and the center arm operates the fuel injector. Each set of three rocker arms pivots on a separate shaft supported by two brackets. Bolts secure each bracket to the cylinder head. The rocker arms are operated by the camshaft through cam followers and short push rods extending through the cylinder head. Contact between each cam follower and the camshaft is effected by hardened roller incorporating a pressed-in bushing, which runs directly on a pin in the lower end of the cam follower. Each follower operated in a bore in the cylinder head. A guide for each set of three cam followers is attached to the bottom of the cylinder head to keep the follower rollers in line with the cams. The rocker arms are lubricated by oil from an oil passage, on the camshaft side of the cylinder

block. Oil from this passage enters the drilled rocker arm shafts through the lower end of the drilled rocker shaft bracket bolts. Excess oil from the rocker arms lubricates the exhaust valve guides and cam followers. Additional cam follower lubrication is provided by oil from grooves in the camshaft bushing bores which is jetted against the cam follower rollers. Clearance between the rocker arms and valves is accomplished by an adjustable clevis on the push rods.

b. *Valves and Valve Springs.* Four exhaust valves are provided for each cylinder. They are actuated in transverse pairs by the valve operating mechanism. The exhaust valve springs are held in place by the valve spring caps and tapered two-piece valve locks. Excess oil from the rocker arms lubricates the exhaust valve stems. The exhaust valves are ground to seat on the valve seat inserts which are pressed in the cylinder head. Prefinished replaceable valve guides are pressed into the cylinder head.

**NOTE**

Several operations may be performed without removing the cylinder head.

1. Adjusting valve clearance.
2. Removing and installing valve springs.
3. Removing and installing rocker arm shaft or shaft bracket.
4. Removing and installing an injector.

It is also possible to replace a push rod, spring, spring seats, and cam follower without removing the cylinder head. However, these parts are more easily changed from the lower side of the head.

#### **4-37. Rocker Arms, Push Rods, and Cam Followers**

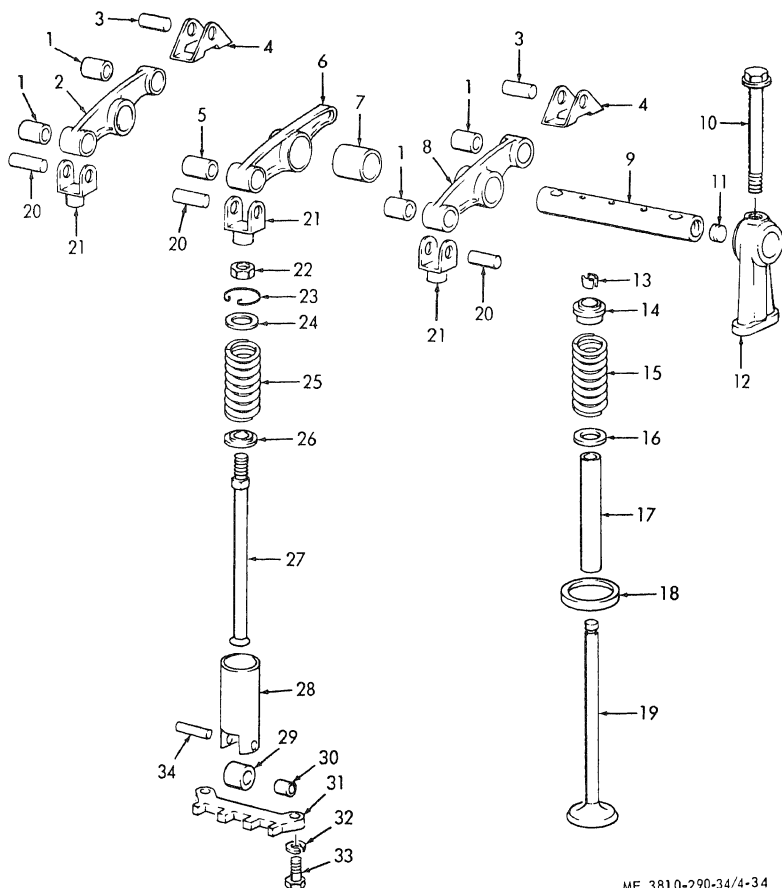
##### **a. Removal.**

(1) Remove the cylinder head (para 4-35).

(2) Remove the bolts (10, fig. 4-34) that secure the rocker arm shaft brackets (12) to the cylinder head. Remove the brackets.

(3) Slide the rocker arm shaft (9) out of the rocker arm assembly.

(4) Place the cylinder head on its side and remove the capscrews (33) and lockwashers (32) that secure the cam roller guide (31) to the cylinder head. Remove the guide and cam push rod follower assemblies (28) from the head.



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*Figure 4-34. Rocker arms, push rods, cam followers, valves, and valve springs, exploded view.*

## Key to figure 4-34

1. Bushing (15)
2. Arm, R.H. (3)
3. Pin (6)
4. Bridge (6)
5. Bushing (3)
6. Arm (3)
7. Bushing, Large (3)
8. Arm, L.H. (3)
9. Shaft (3)
10. Bolt (6)
11. Plug (3)
12. Bracket (6)
13. Lock (24)
14. Seat (12)
15. Spring (12)
16. Seat (12)
17. Guide (12)
18. Valve seat insert (12)
19. Valve (12)\*
20. Pin (9)
21. Clevis (9)
22. Nut (9)
23. Retainer (9)
24. Seat (9)
25. Spring (9)
26. Seat (9)
27. Push rod (9)
28. Follower assembly (9)
29. Roller (9)
30. Pin (9)
31. Guide (3)
32. Lockwasher (6)
33. Capscrew (6)
34. Bushing (9)

## NOTE

Quantities for one head assembly

\*Available in valve parts kit.

(5) Loosen the nuts (22) and unscrew each of the push rods (27) from the clevises (21). Remove the push rod and spring assemblies from the cylinder head.

(6) Repeat the operation on the remaining rocker arm assemblies.

(7) Remove the spring seat retainer rings (23) from the cylinder head.

*b. Disassembly.*

(1) Depress the spring (25) and remove the nut (22) and push rod spring seat (24) from the push rod (27). Separate the compression spring (25), push rod spring seat (26), and push rod (27).

(2) Drive the straight headless pin (34) from the cam push rod follower assembly (28) and separate the cam follower roller (29) from the follower.

(3) Press the straight headless pins (20) from

the rod end clevises (21) and remove the clevises from the rocker arms.

(4) Press pins (3) from bridges (4) and rocker arms (2 and 8).

(5) Remove the sleeve bushings (1 and 5) from the rocker arms.

(6) Remove the sleeve bushing (7) from the fuel injector rocker arm (6).

(7) Disassemble the remaining rocker arm assemblies in the same manner as described above.

*c. Cleaning, Inspection, and Repair.*

(1) Wash all parts thoroughly with an approved cleaning solvent and dry thoroughly.

(2) Clean all lubricating oil passages with compressed air or, if necessary, use a wire probe.

(3) Examine the bushings and pins of the rocker arms and if scored, pitted, or scratched, replace them.

(4) Examine the rocker arm exhaust valve and injector contact surfaces where they contact the valve poppet and plunger lifter and if damaged or worn, grind to the original contour or replace them.

(5) Inspect the valve push rods for wear or scoring. If the push rods have "shoulders" or "ridges" due to the rocker arm action on the push rods, replace the push rods. Replace a bent push rod.

(6) Examine the cam follower rollers and pins for scored, pitted, scratched, cracked, or out-of-round surfaces. Replace a damaged roller or pin.

(7) Examine the compression springs (25) for cracks, breaks, pitting, bent condition, or weakness. Replace a damaged spring.

(8) Examine all hardware, for cracks, breaks, and stripped or crossed threads. Replace all damaged hardware.

## NOTE

The maximum allowable clearance between the rocker arm shaft and rocker arms (with or without bushing) is 0.004 inch. Replace shaft, bushing or rocker arm if this clearance is exceeded.

*d. Assembly.*

(1) Press the bushings (5 and 7) in the fuel injector rocker arm (6).

(2) Press the bushing (1) in the exhaust valve rocker arm assemblies.

(3) Position the clevises (21) on the rocker arm assemblies and install the straight headless pins (20).

(4) Assemble the push rod spring seat (26), compression spring (25) and push rod spring seat (24) on the push rod (27). Compress the spring and secure to the push rod with the nut (22).

(5) Aline the cam follower rollers (29) in the

cam push rod follower assemblies (28) and secure with the straight headless pins (34).

(6) Reassemble the remaining rocker arm assemblies in the same manner as described above.

*e. Installation.*

(1) Install the spring seat retaining ring (23) in the push rod openings in the cylinder head.

(2) Slide the push rod and spring assemblies into position from the bottom of the cylinder head.

**NOTE**

The injector rocker arm assemblies are slightly different from the exhaust valve rocker arms. The boss for the shaft on the exhaust valve rocker arms is longer on one side of the arm than on the other.

The extended boss on each of the valve rocker arms must face the injector rocker arms.

(3) Turn the nut (22) on to the push rod as far as possible and screw the push rod into the rod end clevis (21) until the end of the push rod contacts the rocker arm.

**NOTE**

There is an oilhole in the bottom of the cam follower. Install the cam follower with the oilhole pointing away from the valve, so that the hole is not covered by the follower guide.

(4) With the cam follower rollers (29) pointing across the cylinder head, slide the cam push rod follower assemblies (28) into position over the push rod and spring assemblies.

(5) Position the cam roller guides (31) on the bottom of the cylinder head and secure with the cap screws (33) and lockwashers (32).

(6) Lubricate the outer surface of the rocker arm shafts (9) and install in the shaft openings in the rocker arms (2, 6 and 8).

(7) Install a shaft bracket (12) on each end of the rocker arm shaft. Aline the brackets with mounting holes in top of the cylinder head and fasten with the bolts (10). Torque the bolts to 50-55 pound-feet.

(8) Install the cylinder head assembly (para 4-35).

## 4-38. Valves and Valve Springs

### *a. Removal.*

(1) Remove the cylinder head and sub-assemblies (para 4-35).

(2) Support the bottom of the cylinder head on a workbench with a two-inch block placed between the valve head and the workbench.

(3) Thread a valve spring compressor adapter into the rocker arm shaft bolt hole in the cylinder head. Press the handle of the compressor adapter to compress the valve spring (15, fig. 4-34) and remove the two valve seat locks (13).

(4) Release the spring compressor adapter and

remove the spring cap (14), valve spring (15), and spring seat (16).

(5) Number the exhaust valves so they can be installed in the same location.

(6) Remove the exhaust valves (19).

### *b. Cleaning, Inspection, and Repair.*

(1) Carefully scrape and wire brush all grime and carbon deposits from the valve stems.

(2) Clean the valves with an approved cleaning solvent and wipe dry.

(3) Inspect each valve for cracked, pitted, cupped, and excessively thin face. Examine the valve stem for scoring, warpage, or excessive wear. Carbon on the face of the valve indicates a faulty seat and a resultant lead or "blow-by". Replace a damaged valve or reface the valve to an angle of 30° as instructed in c below.

### **CAUTION**

The valve face angle must be identical to the valve seat insert angle. See figure 4-33C.

(4) Replace any valves worn beyond the tolerances specified.

(5) If a new valve is installed, the valve head must not protrude above the surface of the cylinder head. The valve seat diameter on a used valve will decrease after several reconditionings, so that the valve will rest in a lower position on the valve seat insert. It must not exceed 0.0240 of an inch below the cylinder head surface. Replace the valve if these limits are exceeded.

(6) Examine the valve springs for pitted or broken coils, and inadequate tension. Check the tension with a spring tester and accurate torque wrench. Replace any spring if a load of less than 25 pounds will compress the spring to less than 1.93 inches.

### *c. Valve Refacing.*

(1) Install the valve in a valve refacer tool, making sure the grinding wheel is properly trued, and set the chuck at 30° angle. Then take a light cut from the face of the valve, removing a small amount of material from the valve face.

(2) Remove the valve from the facing tool and make the prussian blue test as described for the valve seat insert in paragraph 4-35 c (9). Regrind the valves if necessary.

### *d. Installation.*

(1) Apply a light coat of engine oil to the stem of the valve (19) and slide the valve into the installed valve guides.

(2) Hold the valve in place with a strip of masking tape and turn the bottom of the cylinder head down on the workbench.

(3) Install the valve spring seat (16) and valve spring (15) on the valve stem. Install the valve spring cap (14) in the valve spring.

(4) Compress the valve spring with valve spring compressor and install the valve spring locks (13) in the valve spring cap and recess of the valve spring to lock the valve spring in place.

(5) Remove the valve spring compressor by removing the rocker arm shaft bracket bolt.

(6) Install all valves according to the procedure described in (1) through (5) above.

NOTE

Adjust valve clearance  
XXVII.

(7) Install the sub-a head (para 4-35).

## Section XVIII. FUEL INJECTORS AND INJECTOR CONTROLS

### 4-39. Injector Controls

*a. General.* An injector control tube and lever assembly is mounted on each cylinder head, and serves as an adjustable control element between the governor and throttle controls, and the fuel injectors. A minimum amount of maintenance is required for these units, and their removal will usually be required only when a cylinder head is removed.

#### *b. Removal.*

- (1) Remove rocker arm covers (para 4-34).
- (2) Remove cotter pins (1, fig. 4-35) and clevis pins (2). Disengage the link (14) from the lever (3).
- (3) Remove four bolts (9) and lockwashers (10).

(4) Slide the assembly endwise to d the injector rack levers from the levers (1) and remove the assembly.

#### *c. Disassembly.*

- (1) Remove pin (4), lever (3), and spring (5).
- (2) Remove the brackets (11) and screws (12).

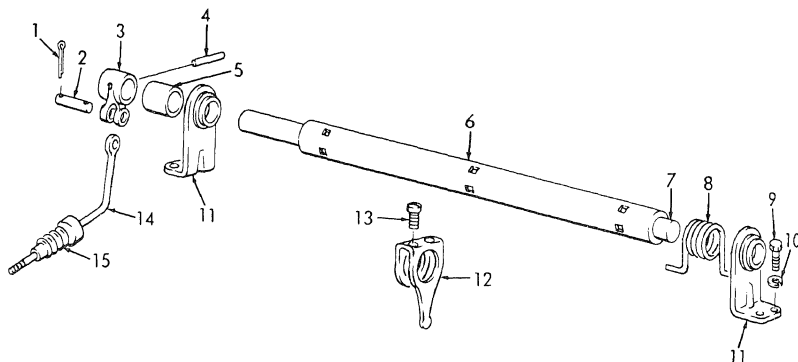
NOTE

It is not necessary to remove the levers (1) if their replacement is required.

- (3) Remove six screws (13) and control tube (12) from control tube (6).

#### *d. Cleaning, Inspection, and Reassembly.*

- (1) Clean all parts with an appropriate solvent. Dry thoroughly.



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1. Cotter pin
2. Clevis pin
3. Lever
4. Pin
5. Spacer
6. Tube assembly
7. Pin
8. Spring

9. Bolt (4)
10. Lockwasher (4)
11. Bracket (2)
12. Lever (3)
13. Screw (6)
14. Link
15. Boot

Figure 4-35. Injector control tube and lever assembly, exploded view.

(2) Inspect all parts for wear and damage. Inspect the spring for cracks in the coils. Replace parts as required.

*e. Assembly.* Assemble the control tube in the reverse order of disassembly.

*f. Installation.*

(1) Install the tube assembly on the cylinder head.

(2) After engaging the levers (12) on the injector rack levers, install the bolts (9) and lockwashers (10). Tighten finger-tight only.

(3) Hook one end of the tube return spring (8) around the injector control lever (13) and the other end around the bracket (11).

(4) Tighten the bolts (9) to 10—12 pound-feet torque.

(5) Check the operation of the control tube assembly by turning the unit so that the injector rack levers are moved all the way in (FULL FUEL POSITION). Release the control tube to see if the return spring will pull the injector rack levers all the way out (NO FUEL POSITION).

NOTE

The injector control tube is mounted in self-aligning bearings and tapping the tube lightly with a soft hammer will remove any bind that exists. The injector racks must return to the NO FUEL POSITION freely by aid of the spring only. Do not bend the spring to correct any binding condition.

(6) Final adjustment of the control tube levers will be made in accordance with the instructions in section XXVII.

#### 4-40. Fuel Injectors

*a. General.* The fuel injector assembly is a lightweight compact unit and performs the following functions:

(1) Creates the high fuel pressure required for efficient injection.

(2) Meters and injects the fuel to the exact amount required to handle the load.

(3) Atomizes the fuel for mixing with the air in the combustion chamber.

(4) Permits continuous fuel flow.



**CAUTION**

Injectors are identified by a circular disc pressed into a recess at the front side of the injector body (refer to TM5-3810-290-12 for correct type number). Use only the type specified, and never mix types.

**b. Removal.**

- (1) Remove the rocker arm covers (para 4-34).
- (2) Remove the fuel pipes from injector and fuel connectors (fig. 4-36).

**CAUTION**

Cover injector filter caps with shipping caps and protect fuel pipes and connectors to prevent entry of dirt or foreign material.

- (3) Rotate engine with starting motor until push rod ends, injector and valve, are aligned horizontally.

- (4) Remove the rocker shaft bracket bolts (10, fig. 4-34) and swing the rocker arm assembly away from the injector and valves (fig. 4-36).

- (5) Loosen the injector clamp bolt (3, fig. 4-38) and remove the bolt, special washer (2), and clamp (1).

- (6) Loosen the adjusting screws (fig. 4) the injector rack control lever and slide it away from the injector.

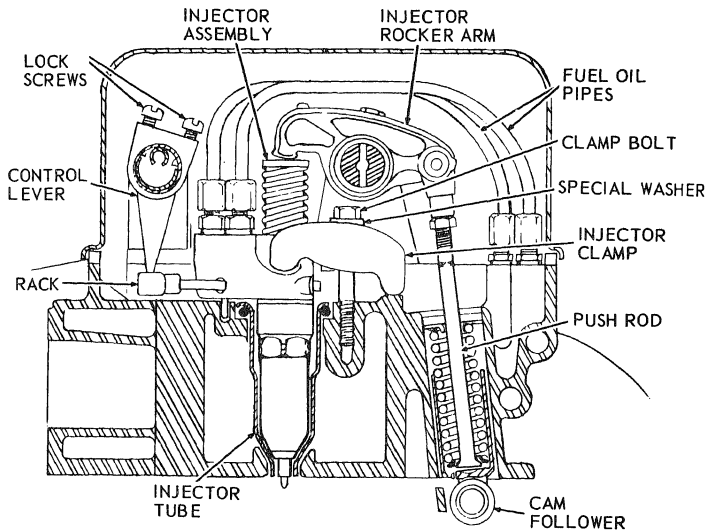
- (7) Free the injector from its seat and from cylinder head.

- (8) Cover injector hole in cylinder head prevent dirt or foreign material from entering. *Initial Inspection and Testing.*

- (1) Clean the exterior of the injector approved cleaning solvent. Dry thoroughly, compressed air.

- (2) If inspection of the injector does not show any external damage, then a series of tests must be made to determine the condition of the injector prior to disassembly and overhauling.

- (3) Place the injector in an injector rack. Hold the injector control rack (8, fig. 4-37) in the "NO FUEL" position and depress the follower to the bottom of its stroke. Release the follower while moving the control rack back and forth, until the follower reaches the top of its travel. IF the rack does not move freely, that the internal parts of the injector are dirty.



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Figure 4-36. Fuel injector, removal points.

(4) Check the injector valve opening pressure. With the control rack in the "FULL FUEL" position, pump the handle of the tester and note the injector valve (19) opening pressure as indicated when the injector sprays fuel. The pressure should be 450-850 pounds per square inch.

#### WARNING

The injector must be positioned properly with relation to the spray deflector before testing. High pressure fuel spray penetrating the skin can cause serious infection.

(5) Check the injector valve holding pressure by operating the tester pump handle until the pressure is just below the valve opening pressure. Close the fuel shut-off valve on the tester and note

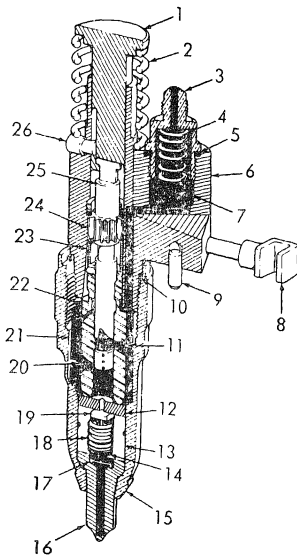
the time required for the pressure to drop. A pressure drop from 450 p.s.i. to 250 p.s.i. should not be less than 40 seconds.

(6) Check the injector for leaks by pumping up the pressure on the tester to 1600—2000 p.s.i. and inspect the injector for leaks.

(7) Check the spray pattern by placing the control rack in the "FULL FUEL" position and pumping the fuel pressure just below the injector valve operating pressure. Operate the injector plunger and observe the spray pattern which should be uniform.

#### NOTE

If any of the above tests indicate any sign of malfunctioning, then the injector should be disassembled, repaired, or replaced.

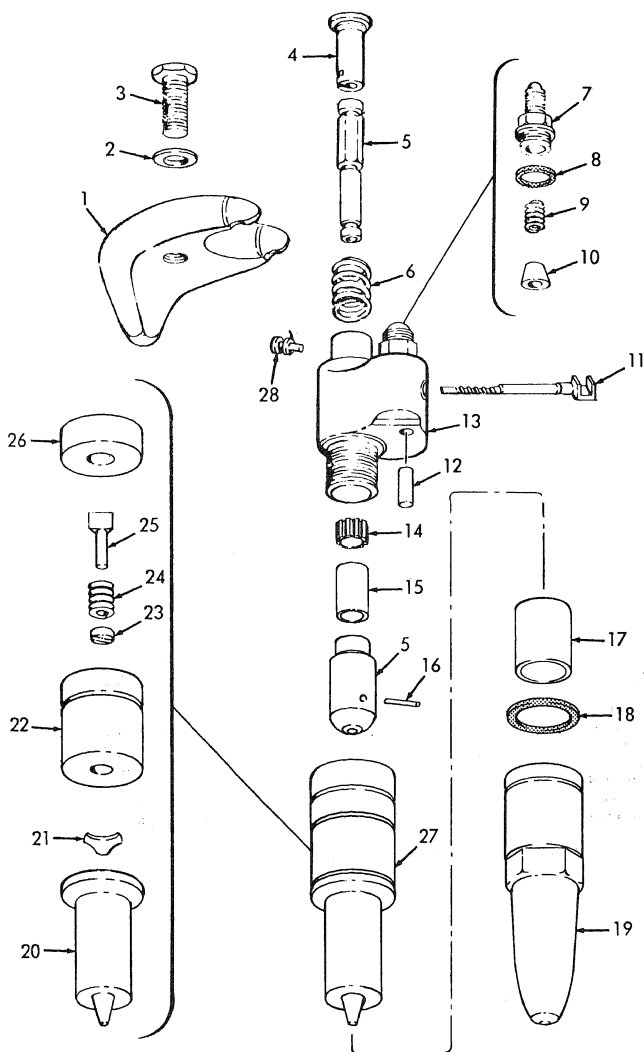


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1. Follower
2. Follower Spring
3. Filter cap (2)
4. Spring (2)
5. Gasket (2)
6. Body assembly
7. Filter element (2)
8. Control rack
9. Dowel
10. Seal
11. Upper port
12. Valve seat
13. Valve cage

14. Valve stop
15. Nut
16. Spray tip
17. Check valve
18. Valve spring
19. Injector valve
20. Lower port
21. Spill deflector
22. Plunger bushing
23. Gear retainer
24. Gear
25. Plunger
26. Stop pin

Figure 4-37. Fuel injector assembly, cross-sectional view.



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Figure 4-38. Fuel injector assembly, exploded view.

Key to figure 4-38.

1. Clamp
2. Washer
3. Bolt
4. Follower
- \*5. Plunger and bushing assembly
6. Following spring
7. Filter cap (2)
8. Gasket
9. Spring
10. Filter element (2)
11. Control rack
12. Pin
13. Body assembly
14. Gear
15. Gear retainer
- \*16. Pin
17. Spill deflector
18. Preformed packing
19. Nut
20. Spray tip
21. Check valve
22. Valve cage
23. Valve stop
24. Valve spring
25. Injector valve
26. Valve seat
27. Valve assembly
28. Stop pin

\* Not serviced separately.

#### d. Disassembly.

(1) Place the injector assembly in a holding fixture in an upright position. Remove the filter caps (7, fig. 4-38). Discard gasket (8).

(2) Remove the helical compression spring (9) and fuel injector filter element (10) from the recess in the injector body assembly (13).

(3) Compress the follower helical compression spring (6), then, using a screwdriver, raise the spring above the stop pin (28) and remove the pin. Allow the spring to extend gradually.

(4) Remove the follower (4), plunger (5), and follower spring (6) from the injector body assembly as an assembly, and separate each part.

(5) Invert the injector in the holding fixture and remove the fuel injector retaining nut (19) from the injector body assembly.

#### CAUTION

Lift the injector retaining nut straight up by hand, being careful not to dislodge the spray tip and valve parts.

(6) Lift the spray tip (20), check valve (21), valve cage (22), valve stop (23), valve spring (24), injector valve (25), and valve seat (26).

(7) Remove the spill deflector (17) and preformed packing (18) from the fuel injector retaining nut (19).

(8) Remove the plunger and bushing assembly (5), gear retainer (15), and gear (14), from the injector body assembly.

(9) Remove the control rack (11) and straight headless pin (12) from the injector body assembly.

#### e. Cleaning, Inspection, and Repair.

(1) Discard the filter element. Clean all injector parts with an approved cleaning solvent and dry with filtered compressed air.

(2) Inspect the packing surface of the injector body for burrs or scratches. Inspect the injector body for cracks, breaks, or damaged parts. Replace a damaged injector body.

#### NOTE

Most injector troubles result from dirt particles. Therefore, it is essential that a clean area be provided on which to place injector parts after disassembly and cleaning.

(3) Inspect the spray tip, disk, injector valve cage, spray tip valve, injector valve seat, plunger and bushing assembly, and bushing surface of the injector body with a magnifying glass for scoring or other damage. These parts of the injector have lapped finish and if any of the parts are damaged, new parts must be installed.

(4) Inspect the teeth on the control rack and spur gear for excessive wear or damage. Replace the gear and rack if damaged.

(5) Inspect the spray tip and spray tip seat of the fuel injector retaining nut for carbon deposits. Remove all carbon deposits.

(6) Clean the spray tip orifices, plunger and bushing assembly, and rack opening in the injector body with a suitable tool.

(7) Before installing used valve parts, all sealing surfaces must be lapped, with the exception of the slot in the injector valve seat. If new valve parts are installed, lightly lap the sealing surfaces.

(8) To inspect the plunger and the plunger bushing, install the plunger bushing on the plunger and revolve. The bushing must spin freely on the plunger. The plunger bushing and plunger are matched parts. They must be considered as one piece, and if one is replaced, both must be replaced.

#### CAUTION

Do not handle the plunger excessively as perspiration may cause rust and sticking in the plunger bushing. Immerse injector parts frequently in clean fuel oil to prevent this.

#### f. Assembly.

(1) Dip each part of the injector body assembly in clean fuel oil immediately before it is assembled.

(2) Hold the injector body assembly (13) upright and assemble new fuel injector filter elements (10) in each of the cavities of the injector body. Place a helical compression spring (9) above

each filter element and a new gasket (8) against the shoulder of each filter cap (7); lubricate the threads of the filter injector caps and tighten to the filter body to 65 to 75 pound-feet torque.

#### NOTE

When assembling the filter elements, always position the dimple at the bottom of the fuel opening.

(3) With the injector inverted, slide the control rack (11) through the hole in the body so the two marked teeth are visible. The two teeth of the control rack at matchmarked with the gear (14). For the correct timing, position the marked tooth of the gear between the two marked teeth on the rack.

(4) Position the injector gear retainer (15) down on top of the gear (14) and the plunger and bushing assembly (5) down onto the retainer, with the locating pin in the bushing guided into the slot of the injector body. Slide the spill deflector (17) into the fuel injector retaining nut (19) and the preformed packing (18) on the injector body.

(5) Support the injector body in a holding fixture, valve end up. Place the valve seat (26) on the end of the plunger and bushing assembly (5). Insert the stem of the injector valve (25) in one end of the valve spring (24) and valve stop (23) in the opposite end of the valve spring. Lower the valve cage (22) and position the valve cage on the valve seat.

(6) Centrally located the check valve (21) on the cage and place the spray tip (20) over the valve and against the cage.

(7) Lubricate the thread of the fuel injector retaining nut (19) and pilot the nut over the spray tip. The spray tip will slide through the hole in the small end of the retaining nut.

(8) Screw the retaining nut in place by hand, making sure that the valve assembly does not shift. Do not tighten the nut.

(9) Slide the head of the plunger (5) into the follower (4) and insert the plunger through the follower spring (6).

(10) Invert the position of the injector in the

holding fixture, filter injector cap up, and push the control rack (11) all the way in; insert the free end of the plunger into the top of the injector body assembly (13).

(11) Start the stop pin (28) into position in the injector body so that the bottom coil of the follower spring (6) rests on the narrow flange on the stop pin. Then, with the slot in the follower (4) and the hole in the injector body in alignment for the stop pin and flat side of the plunger positioned to engage the flattened side of the spur gear, press down on the top of the plunger lifter and at the same time press the follower stop pin into position. The stop pin will slip into position as soon as the slot in the followers and hole in the injector body come in alignment. When in place, the spring will hold the stop pin in position.

(12) Invert the fuel injector assembly in the holding fixture and tighten the fuel injector retaining nut (19) to 55-65 pound-feet torque.

(13) Install the straight headless pin (12) into the injector body assembly.

(14) Test the assembled injector as outlined in subparagraph c above.

#### g. Installation.

(1) Before installing a fuel injector assembly, be sure that the beveled seat of the injector tube is free from dirt and carbon deposits.

(2) Position the injector assembly in the injector tube with the locating pin registering with the locating hole in the cylinder head, and with the pin on the injector control rack.

(3) Install the fuel injector in the reverse order of removal.

#### CAUTION

**Overtightening of the injector clamp capcrew may cause the injector rack to bind and result in uneven running of the engine.**

(4) Time the replaced injector assemblies and perform the interlocking adjustments as outlined in Section XXVII.

## Section XIX. CRANKCASE OIL PAN AND OIL INLET TUBE

### 4-41. Crankcase Oil Pan

#### a. Removal.

(1) Remove drain plugs (4, fig. 4-39) and drain oil pan.

(2) Remove elbows (6 and 8) and pipe (7).

(3) Remove screws (3), lockwashers (2), oil pan (5) and gasket (1). Discard the gasket.

#### CAUTION

**Do not damage oil inlet tube and screen when removing pan.**

#### b. Cleaning, Inspection, and Repair.

(1) Clean the oil pan with an approved cleaning solvent. Dry with compressed air.

(2) Inspect the oil pan for porosity or cracks.

(3) Remove all traces of gasket material from bottom of engine block and oil pan.

(4) Inspect the machined edge of the oil pan for warpage or unevenness by placing on a surface plate or other large flat surface.

(5) Inspect the drain plugs for damaged threads.

*c. Installation.*

(1) Affix a new gasket (1) to the oil pan (5).

(2) Install the oil pan with the screws (3), lockwashers (2). Tighten the screws alternately and evenly to avoid damaging the gasket or springing the pan.

(3) Install elbows (6 and 8) and pipe (7).

(4) Replace and tighten the drain plugs (4).

(5) Service the crankcase in accordance with the current lubrication order. Start the engine and check the oil pan for leaks.

**4-42. Oil Inlet Tube and Screen**

*a. Removal.*

(1) Drain crankcase and remove oil pan (para 4-41).

(2) Remove the capscrews (1 and 4, fig. 4-40) and lockwashers (2 and 5).

(3) Remove the tube and screen as an assembly.

*b. Disassembly.*

(1) Remove the capscrews (6) and lockwashers (7).

(2) Remove the screen (8) and gasket (9). Discard the gasket.

*c. Cleaning, Inspection, and Repair.*

(1) Clean all parts with an approved cleaning solvent. Dry thoroughly with compressed air.

(2) Inspect the tube and screen for damage (cracks, punctures, etc.). Replace as required.

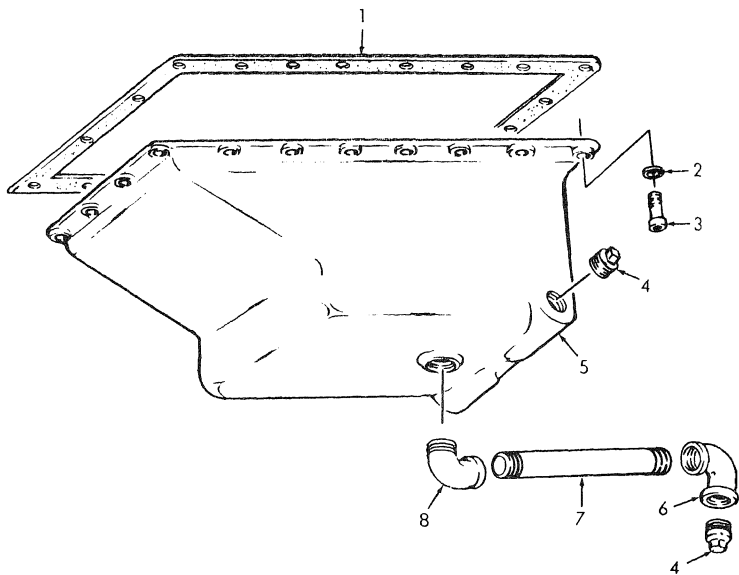
(3) Clean the tube and screen thoroughly to insure that no deposits will impede the flow of oil.

*d. Assembly.*

(1) Install the screen (8), new gasket (9) on the oil inlet tube (3).

(2) Attach the assembly to the support bracket (10) with capscrews (6) and lockwashers (7).

*e. Installation.* Install the assembly in the reverse of removal.



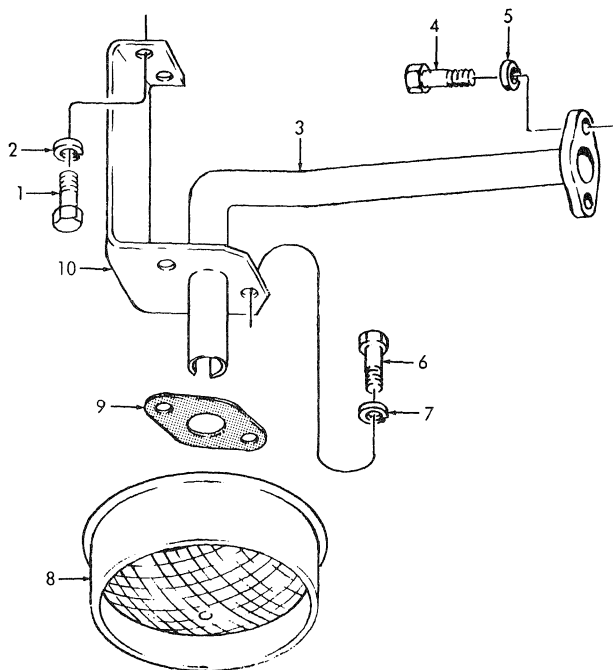
ME 3810-290-34/4-39

1. Gasket
2. Lockwasher (22)
3. Screw (22)
4. Plug (2)

5. Oil pan
6. Elbow
7. Pipe
8. Elbow

Figure 4-39. Crankcase oil pan, exploded view.





ME 3810-290-34/4-40 :

1. Capscrew
2. Lockwasher
3. Inlet tube
4. Capscrew
5. Lockwasher

6. Capscrew
7. Lockwasher
8. Screen
9. Gasket
10. Bracket

Figure 4-40. Oil pump inlet tube and screen assembly, exploded view.

## Section XX. FLYWHEEL AND FLYWHEEL HOUSING

### 4-43. Flywheel

a. *General.* The flywheel is attached to the rear end of the crankshaft with six bolts, and is machined to provide a true alignment with a torque converter drive. A ring gear is secured to the flywheel periphery to engage with the starting motor drive for cranking purposes.

#### NOTE

The rugged construction of the flywheel makes necessity for service on this part very remote. However, its removal is required for other service functions.

#### b. *Removal.*

(1) Remove the bolts (8, fig. 4-41) and scuff plate (7). Reinstall one bolt.

(2) Attach a lifting tool to the flywheel. Attach a chain hoist or other lifting device to the lifting tool and remove the one bolt.

(3) Withdraw the flywheel (6) from the crankshaft and flywheel housing.

*c. Cleaning, Inspection, and Repair.*

(1) Clean all parts with an approved cleaning solvent. Dry thoroughly with compressed air.

(2) Inspect the flywheel for cracks or scoring.

**NOTE**

If any machining is required, do not remove more than 0.020 inch of material and maintain all radii.

(3) Inspect the ring gear for cracked, broken or missing teeth. Replace as required.

**Key to figure 4-41.**

1. Gasket
2. Gasket
3. Housing
4. Lockwasher
5. Bolt
6. Flywheel
7. Plate
8. Bolt
9. Plug

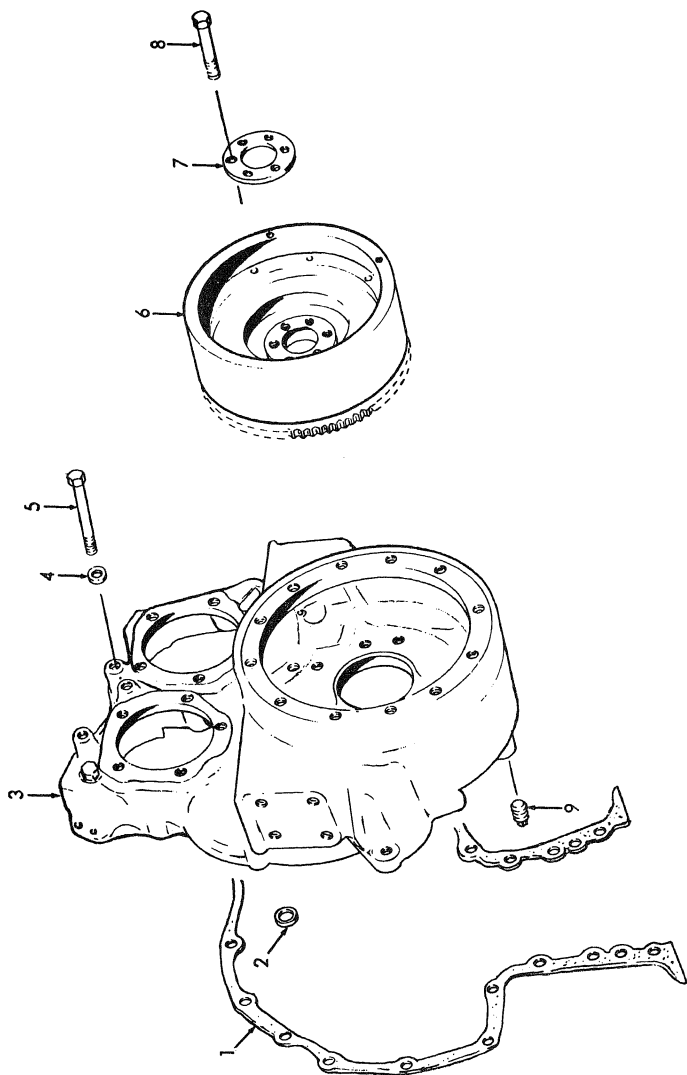


Figure 4-41. Flywheel and flywheel housing, exploded view.

ME 3810-290-34/4-1

(4) To replace the ring gear, support the flywheel, crankshaft side down, on a solid flat surface slightly smaller in diameter than the ring gear. With a suitable drift and hammer, drive the ring gear off the flywheel, working progressively around the circumference to avoid binding.

(5) To install new ring gear, support flywheel on solid, flat metal surface, ring gear side up.

#### NOTE

Do not overheat gear. Keep below 400 degrees F.

Use a "heat" crayon to avoid overheating.

(6) Heat ring gear uniformly with acetylene torch.

(7) Place expanded ring gear on flywheel and tap into place against shoulder of flywheel.

d. *Installation.* Install the flywheel in reverse order of removal. Tighten bolts to a torque of 130-140 pound-feet.

### 4-44. Flywheel Housing

#### a. Removal.

(1) Remove the starting motor from the flywheel housing (para 4-13).

(2) Remove the oil pan (para 4-41).

(3) Remove the fuel pump (para 4-23).

(4) Remove the power steering pump (para 4-17).

(5) Remove the tachometer drive assembly (para 4-19).

(6) Remove the flywheel (para 4-43).

(7) Remove the flower drive cover, blower drive shaft retainer ring, blower drive shaft, and blower drive support (para 4-30).

(8) Thread two pilot studs into the cylinder block to guide the flywheel housing until the oil seal clears the end of the crankshaft.

(9) Insert eyebolts into tapped holes of flywheel housing. Attach a sling and suitable lifting device.

(10) Remove all of the bolts attaching the housing to the cylinder block.

Table 4-3. Flywheel Housing Bolt Data

| Bolt size             | Quantity used |
|-----------------------|---------------|
| 5 / 16-18 X 2 1/2 Lg. | 2             |
| 3/8-16 X 2 1/2 Lg.    | 12            |
| 3/8-16 X 2 3/4 Lg.    | 2             |
| 3/8-16 X 3 1/4 Lg.    | 6             |
| 3/8-24 X 3 1/4 Lg.    | 2             |

#### NOTE

When removing the above bolts, note the location

(11) Tap each side of the housing alternately with a soft hammer to loosen and work it off the dowel pins.

(12) After removing the housing, remove all traces of old gasket material from the flywheel housing and cylinder block rear end plate. *Discard the gaskets.*

#### b. Cleaning, Inspection, and Repair.

(1) Clean the flywheel housing with an approved cleaning solvent. Dry thoroughly with compressed air.

(2) Inspect the housing for cracks or other damage. Replace if housing is damaged.

(3) Remove the crankshaft rear oil seal (6, fig. 4-51) by placing the housing, flywheel side down, and driving out seal with suitable remover tool.

(4) Clean and inspect bore. Remove all sealant compound.

(5) Turn housing over. Coat outside of new seal lightly with a non-hardening sealant. Position seal with lip facing down. Drive seal into housing, using suitable installation tool, until seal is flush with outside face of housing.

(6) Wipe excess sealant from seal and housing.

#### c. Installation.

(1) Lubricate the gear train teeth with clean engine oil.

(2) Affix new gaskets (1 and 2, fig. 4-41) to the rear face of the cylinder block end plate.

(3) Apply a light coat of cup grease to the crankshaft rear oil seal.

(4) Thread two pilot studs into engine block. Place oil seal expander over end of crankshaft.

(5) Position the flywheel housing over the crankshaft and up against the rear end plate and gaskets, holding the oil seal expander in place by hand.

(6) Install the flywheel housing bolts (5) and lockwashers (4) (table 4-3) and washers.

(7) Start at bolt No. 4 (fig. 4-42A) and draw up the bolts snugly in the sequence shown.

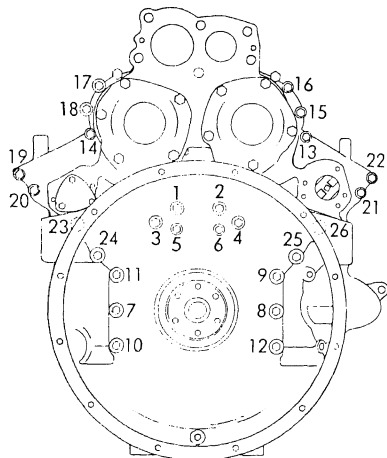
(8) Tighten the bolts, beginning with No. 1 and follow the sequence given in figure 4-42B. Tighten to torques specified in following table 4-4.

Table 4-4. Flywheel Housing Bolt Torque Data

| Bolt No. (fig. 4-42B) | Torque (lb.-ft.) |
|-----------------------|------------------|
| 13, 14                | 19—23            |
| 9 thru 12             | 40—45            |
| Remaining bolts       | 25—30            |

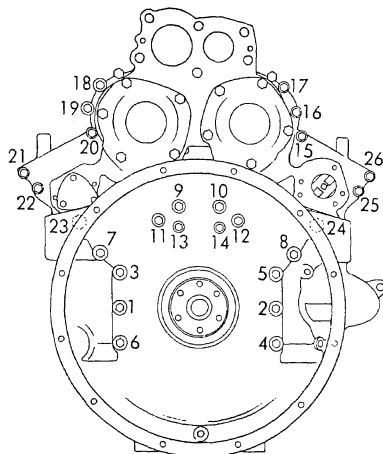
- (11) Install the tachometer drive assembly (para 4-19).  
 (12) Install the fuel pump (para 4-23).  
 (13) Install the power steering pump (para 4-7).

- (14) Install the oil pan (para 4-41).  
 (15) Install the starting motor (para 4-13).



FLYWHEEL HOUSING BOLT TIGHTENING  
SEQUENCE (OPERATION 1)

A



FLYWHEEL HOUSING BOLT TIGHTENING  
SEQUENCE (OPERATION 2)

B

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Figure 4-42. Flywheel housing bolt tightening sequence.

## Section XXI. GEAR TRAIN AND CAMSHAFTS

### 4-45. Gear Train

The gear train consists of a crankshaft timing gear (fig. 4-43) an idler gear, camshaft gears, and accessory drive gear. Since the camshaft gears mesh with each other and run at the same speed as the crankshaft gear; timing marks stamped on the face of the gears (fig. 4-43) must be observed when installing the gears. Gear train noise is usually attributable to excessive gear lash, chipped, burred gear teeth, or excessive bearing wear. When such noise develops, the flywheel housing should be removed and the components of the gear train inspected.

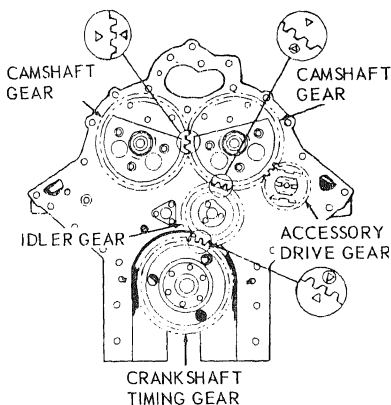
#### NOTE

The backlash between the mating gears of the gear train should be 0.003—0.005 inch. This dimension does not apply to blower drive gears. When one gear is replaced in the gear train, replacement of all gears is recommended.

### 4-46. Camshafts

#### a. Removal.

- (1) Remove fan assembly (para 4-6).
- (2) Remove water pump drive belt (Refer to TM 5-3810-290-12) and water manifold.



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Figure 4-43. Gear train and timing marks.

soft jaws. Drill, tap, and remove the plugs in each end of the camshaft.

#### c. Cleaning, Inspection, and Repair.

(1) Clean all parts with an approved cleaning solvent. Make sure the oil passages in the camshaft are clean and free from any obstructions. Dry thoroughly with compressed air.

(2) Inspect the cam lobes and bearing journals. If badly scored or worn, replace the camshaft. See Table 4-5 below.

#### NOTE

If the cam lobes are scored, inspect the cam followers (para 4-37).

Table 4-5. Camshaft Dimensional And Wear Limit Data

| Item<br>(Standard size)    | New Part            |                     | Wear<br>Limit<br>(inches) |
|----------------------------|---------------------|---------------------|---------------------------|
|                            | Minimum<br>(inches) | Maximum<br>(inches) |                           |
| <b>CAMSHAFT</b>            |                     |                     |                           |
| Shaft diameter at bearings | 2.1820              | 2.1825              |                           |
| Thrust washer thickness    | 0.208               | 0.210               |                           |
| End thrust                 | 0.008               | 0.015               | 0.019                     |
| <b>CAMSHAFT BEARINGS</b>   |                     |                     |                           |
| Bearing-inside diameter    | 2.187               | 2.188               |                           |
| Clearance-bearing to shaft | 0.0045              | 0.006               | 0.008                     |

#### d. Assembly.

(1) Place the rear camshaft spacer (7) and thrust washer (8) over timing gear end of the camshaft (6).

(2) Install the key (5) and gear (10).

(3) Press the camshaft gear (10) against the shoulder on the camshaft and secure with nut (1).

#### e. Installation

(1) Lubricate the camshafts with clean engine oil and insert carefully into the bearings.

#### CAUTION

Be sure the timing marks are properly aligned (fig. 4-43) after the gears are installed.

(2) Install the oil slinger (4) and spacer (3) on both camshafts.

(3) Install the upper front engine cover (para 4-53).

(4) Install the pulleys (2) and keys (5), securing with nuts (2).

(5) Check the clearance between the thrust washer and gear maximum clearance is 0.008 to 0.015 inch with new parts; 0.019 inch with used parts. Secure thrust washer (8) with retaining bolts (9). Tighten bolts to 30—35 pound-feet torque.

(6) Install the retainer plates (11), bolts (13), and lock washers (12). Tighten the bolts to 35-30 pound-feet torque.

(3) Remove alternator (para 4-11).

(4) Remove cylinder heads (para 4-35).

(5) Remove flywheel housing (para 4-44).

(6) Remove the bolts (13, fig. 4-44) and lock washers (12) which attach the gear nut retainer plates (11). Remove the retainer plates.

(7) Wedge a clean rag between the camshaft gears (10) and remove the nuts (1) from each end of the camshaft.

#### NOTE

The two camshafts in the engine are identical with the exception of the drive gears; one is a right-hand helix gear, and the other, a left-hand helix.

(8) With two heavy screwdrivers or pry bars, remove the pulleys (balance weights) (2).

(9) Remove the upper front cover (para 4-53).

(10) Remove the spacer (3) and oil slinger (4) from each camshaft (6).

(11) Remove the thrust washer retaining bolts (9).

(12) Remove the camshaft (6), thrust washer (8) and gear as an assembly from the rear end of the cylinder block.

#### b. Disassembly.

(1) Support the camshaft assembly in an arbor press. Press the camshaft (6) from the gear (10). Remove the thrust washer (8), key (5), and spacer (7) from the camshaft.

## (7) Check backlash between mating gears.

## NOTE

Backlash for new gears is 0.003 to 0.005 inch and not to exceed 0.007 inch for used gears.

(8) Install flywheel housing, cylinder heads, etc. in reverse order of removal (para 4-46 a(1) thru (5)).

**4-47. Camshaft Bearings**

*a. General.* The camshafts are supported by four bearings (bushing-type) (14, fig. 4-44) pressed into bores in the cylinder block. Two intermediate and two end bearings are used for each camshaft.

## NOTE

The camshaft end bearings must be removed prior to the removal of the intermediate bearings.

## CAUTION

When removing bearings be sure to note the position of the bearings in the cylinder bore with respect to the notch in the bearing. All bearings must be replaced in the same position.

*b. Removal.*

(1) Remove the camshafts (para 4-46).

(2) Before removing the camshaft bearings, measure the camshaft bearing journal diameters and inside diameter of the camshaft bearings. If the dimensions do not exceed those given in table 4-5 above, do not replace the camshaft bearings.

(3) If bearing replacement is required, remove the end bearings with a suitable tool set.

(4) Remove the intermediate bearings with the above tool set.

*c. Installation.*

## NOTE

When installing camshaft bearings, the notch must be located in the same position in the bore as the notch in the original bearings.

(1) With installing tool set, install the intermediate bearings in the cylinder block.

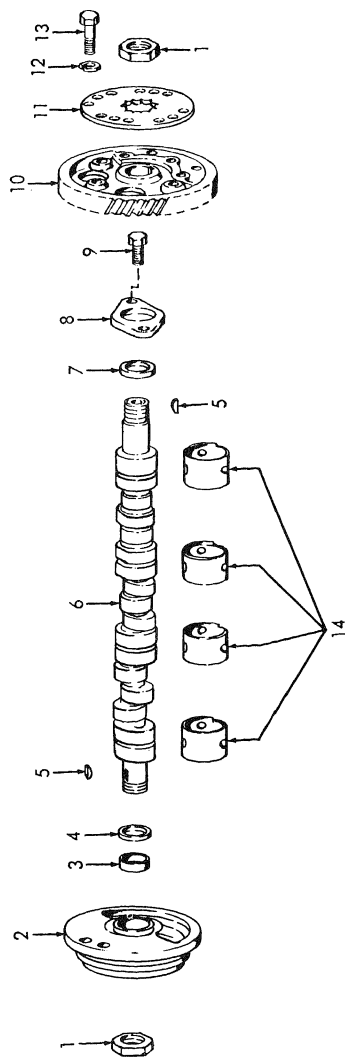


Figure 4-44. Camshaft and bearings, exploded view.



2. Pulley
3. Spacer
4. Slinger
5. Key (2)
6. Camshaft assembly
7. Spacer
8. Thrust washer (2)
9. Bolt (4)
10. Gear (1 R.H. helix and 1 L.H. helix)\*
11. Retainer
12. Lockwasher (4)
13. Bolt (4)
14. Bearing (4)

\*The two assemblies are identical except as noted.

#### NOTE

The right rear and left front intermediate bearings must be 5.54 inches from rear and front face of block respectively. The right front and left rear intermediate bearings must be 6.66 inches from front and rear face of block respectively.

(2) Install the front and rear bearings with installing tool. The bearings when installed properly will be flush with the face of the block.

(3) Install camshafts (para 4-46 e).

### 4-48. Idler Gear

#### a. Removal.

(1) Remove the flywheel housing (para 4-44).

(2) Remove the rear idler thrust washer (1, fig. 4-45).

(3) Slide the idler gear (2) off the hub (4).

(4) Remove the bolt (5) which secures the hub to the cylinder block.

(5) Remove the front thrust washer (1) and hub as an assembly and separate.

#### b. Cleaning, Inspection, and Repair.

(1) Clean all parts with an approved cleaning solvent. Dry with compressed air.

(2) Inspect the gear teeth and bearing (3) for scoring, pitting, and wear. Replace gear and bearing as required.

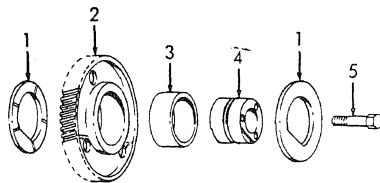
(3) Inspect thrust washers for wear. Replace as required.

#### NOTE

The standard inside diameter of the idler gear bearing is 2.186 inches and the standard outside diameter of hub is 2.1825—2.1835 inches. Maximum wear limit is 0.007 inch. The standard side clearance between thrust washer and idler gear is 0.006—0.013 inch with maximum wear limit of 0.017 inch.

Key to figure 4-45.

1. Thrust washer (2)
2. Gear
3. Bearing
4. Hub
5. Bolt



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Figure 4-45. Idler gear assembly, exploded view.

#### c. Installation.

(1) Position inner thrust washer (1) on forward end of hub (4) with flat inside diameter of thrust washer over the flat of hub and with the oil grooves facing toward the idler gear.

(2) Place the small end of the hub through the rear end plate and align the hub temporarily in the cylinder block with two  $\frac{3}{8}$ -16 x 2 $\frac{1}{2}$  inch pilot bolts.

(3) Secure the hub to the cylinder block with bolt (5). Tighten to 40-45 pound-feet torque and remove the two pilot bolts.

(4) Lubricate the hub and idler gear bearing with clean engine oil.

(5) Install the idler gear (2) on the hub. Make sure the timing marks (fig. 4-43) are matched to the crankshaft timing gear and camshaft gears.

(6) Install second thrust washer (1) on hub with oil grooves facing the idler gear and flat of inside diameter aligned with flat of hub.

(7) Install flywheel housing and accessories as outlined in paragraph 4-44.

### 4-49. Crankshaft Timing Gear

#### a. Removal.

(1) Remove the flywheel housing (para 4-44).

(2) Attach a suitable puller to the crankshaft timing gear and pull the gear from the crankshaft.

#### b. Cleaning and Inspection.

(1) Clean the crankshaft timing gear with an approved cleaning solvent and dry thoroughly.

(2) Inspect the gear teeth for wear, pitting or scoring. Replace as required.

*c. Installation.*

(1) Start the gear on the crankshaft with the timing marks facing out and the keyway aligned with woodruff key in crankshaft.

(2) With a suitable driver, drive the crankshaft timing gear up against the shoulder on the crankshaft.

(3) Install the flywheel housing and accessories as outlined in paragraph 4-44.

#### 4-50. Accessory (Fuel Pump) Drive Gear

*a. Removal.*

(1) Remove the flywheel housing (para 4-44).

(2) Remove two capscrews (22), (fig. 4-22) and drive adapter (23) from the gear (27).

(3) Remove the retaining bolt (24), washer (25), thrust washers (26), gear (27), and hub (28) from the rear end plate.

*b. Cleaning, Inspection, and Repair.*

(1) Clean all parts with an approved cleaning solvent and dry thoroughly with compressed air.

(2) Remove scoring with fine crocus cloth.

(3) Inspect thrust washers (26) for excessive wear. Thrust washers must be 0.158—1.060 inch thick. Replace thrust washers if worn beyond 0.158 inch in thickness.

(4) Inspect the drive gear bearing and hub for wear. Inside diameter of bearing must be 1.122—1.123 inches and the outside diameter of gear hub must be 1.1200—1.1205 inches. Clearance between hub and drive gear bearing is 0.002—0.003 inch for new parts with a maximum wear limit of 0.007 inch. Replace parts worn beyond above limits.

**NOTE**

Drive gear and drive gear bearing must be replaced as an assembly.

*c. Installation.*

(1) Lubricate the drive gear, bearing thrust washers, and hub with clean engine oil.

(2) Assemble the thrust washers (26) and gear (27) on the hub (28) with the oil grooves in the thrust washers facing the gear.

(3) Install the hub and gear assembly in the end plate and block with the drive gear teeth in mesh with the right camshaft gear.

(4) Secure in place with washer (25) and bolt (24). Tighten the bolt to 71-75 pound-feet torque.

(5) Measure clearance between gear and thrust washers. This should be 0.011—0.022 inch.

(6) Attach the drive adapter (23) to the drive gear with two capscrews (22).

(7) Install the flywheel housing and accessories as outlined in paragraph 4-44.

## Section XXII. CRANKSHAFT PULLEY AND TRUNNION MOUNT

#### 4-51. Crankshaft Pulley

*a. Removal.*

(1) Remove fan drive belts (refer to TM 5-3810-290-12).

(2) Remove the crankshaft retaining bolt (1, fig. 4-46), washer (2), and pulley (3) from the crankshaft.

*b. Cleaning, Inspection, and Repair.*

(1) Clean all parts in an approved cleaning solvent and dry thoroughly.

(2) Inspect pulley for cracks, worn grooves, or sharp edges that may damage fan belts. Replace a pulley that is cracked or worn.

*c. Installation.*

(1) Install pulley (3) on crankshaft and secure with washer (2) and retaining bolt (1). Torque the bolt to 200-220 pound-feet torque.

(2) Install and adjust fan belts (refer to TM 5-3810-290-12).

#### 4-52. Front Trunnion Mount

*a. Removal.*

(1) Remove crankshaft pulley (para 4-51).

(2) Remove two capscrews (6, fig. 4-46), lockwashers (5), trunnion cap (4), and trunnion base (11).

(3) Use a flat screwdriver and pry the ring cushion (10) from the front engine support (7).

(4) Remove six capscrews (9), lockwashers (8), and the front engine support (7) from the lower front engine cover.

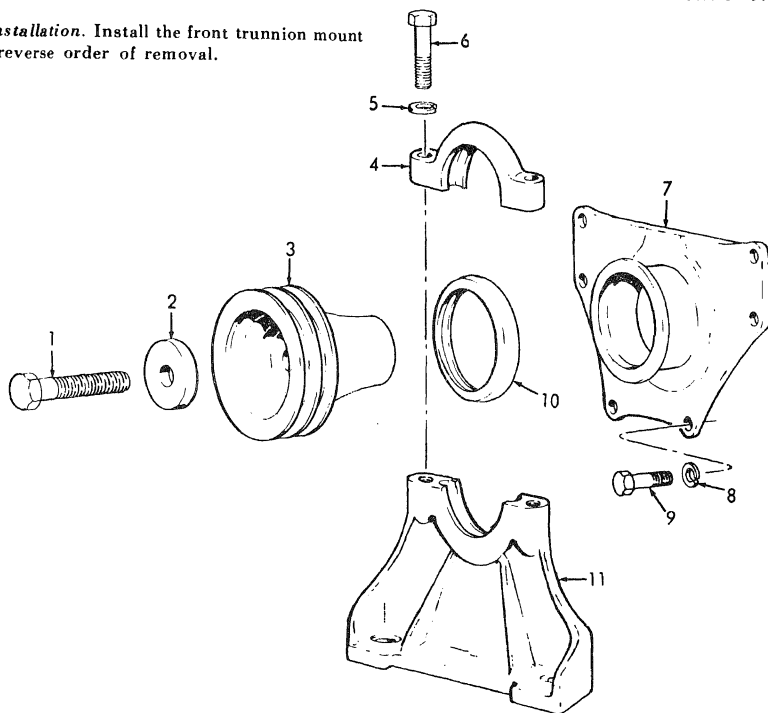
*b. Cleaning, Inspection, and Repair.*

(1) Clean all metal parts with an approved cleaning solvent and dry with compressed air.

(2) Clean the rubber ring (10) with a damp cloth and dry.

(3) Inspect all parts for cracks and wear. Replace as required.

c. *Installation.* Install the front trunnion mount in the reverse order of removal.



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1. Bolt
2. Washer
3. Pulley
4. Cap
5. Lockwasher (2)
6. Capscrew (2)

7. Support
8. Lockwasher (6)
9. Capscrew (6)
10. Ring cushion
11. Base

Figure 4-46. Crankshaft pulley and front trunnion mount, exploded view.

### Section XIII. FRONT COVERS, OIL PUMP, AND OIL PRESSURE REGULATOR VALVES

#### 4-53. Front Covers

a. *General.* The front cover is divided into an upper cover, which carries the camshaft seals; and the lower cover houses the lubricating oil pump. Removal of the upper cover can be accomplished without removal of the engine, however engine removal is necessary for removal of the lower cover.

#### b. Upper Front Cover.

##### (1) Removal.

(a) Remove the fan assembly (para 4-6).

(b) Remove the alternator drive belts (Refer to TM 5-3810-290-12).

(c) Remove the water pump drive belts (Refer to TM 5-3810-290-12).

(d) Remove the nuts (1, fig. 4-44) and pulleys (2) from the camshaft assemblies. Remove key (5).

(e) Remove the capscrews (6, 7, and 8, fig. 4-47) and lockwashers (5).

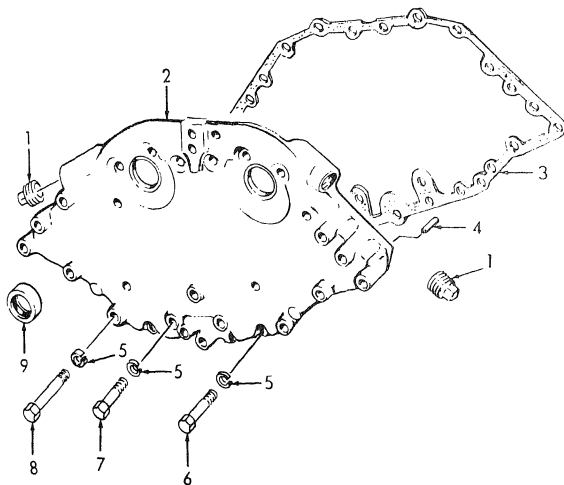
(f) Tap the front cover (2) with a soft hammer and remove from cylinder block with gasket (3). Discard the gasket.

(g) Remove the oil seals (9) by supporting the inner face of the cover on wood blocks and driving the seals out with a suitable driver.

(2) *Cleaning, Inspection, and Repair.*

(a) Clean all parts with an approved cleaning solvent and dry thoroughly.

(b) Inspect the cover for cracks or damaged edges on machined surfaces. Replace as required.



- 1. Plug (2)
- 2. Upper front cover
- 3. Gasket
- 4. Pin (2)
- 5. Lockwasher

- 6. Capscrew (10)
- 7. Capscrew (10)
- 8. Capscrew (5)
- 9. Seal (2)

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Figure 4-47. Upper front engine cover, exploded view.

(3) *Installation.*

(a) Install new seals (9) in the cover by coating the bore in the cover with a non-hardening sealant. Position a new seal, with lip facing toward

(c) Wipe off excess sealant.

(d) Install new gasket (3) on cover.

(e) Install cover on engine and secure with capscrews (6, 7 and 8) and lockwashers (5). Tighten to 25 ft. lbs. torque.

*c. Lower Front Cover.*

*(1) Removal.*

*(a)* Remove fan belts (refer to TM 5-3810-290-12).

*(b)* Remove the crankshaft pulley retaining bolt (1, fig. 4-46) and washer (2), and pulley (3) from the crankshaft.

*(c)* Remove the front trunnion mount (para 4-52).

*(d)* Remove the oil pan (para 4-41).

*(e)* Remove the oil inlet tube and screen (para 4-42).

*(f)* Remove twelve capscrews (17, fig. 4-48) and lockwashers (16).

*(g)* Strike the cover assembly with a soft hammer to free the cover from the dowels in the front of the block. Pull the cover assembly straight off the end of the crankshaft.

*(h)* Remove and discard gasket (3).

*(2) Disassembly.*

*(a)* Remove the oil pump assembly (para 4-54).

*(b)* Remove the two oil pressure regulator valves (para 4-55).

*(c)* Remove the crankshaft front seal (1) by supporting the front cover (2), front down, on two wood blocks. Drive the seal out with a suitable tool.

*(3) Cleaning, Inspection and Repair.*

*(a)* Clean all parts with an approved cleaning solvent and dry thoroughly.

*(b)* Inspect cover for cracks or burrs, at oil seal bore, valve bores, and on machined surfaces. Inspect drilled and tapped holes for cracks or damaged threads. Replace as required.

*(4) Assembly.*

*(a)* Coat the oil seal bore with non-hardening sealant.

*(b)* Place the cover (2) inner face down, in an arbor press and press the oil seal (1) into the cover until flush with the outside face of cover. The seal must be installed with the seal lip toward the inner face of the cover.

**NOTE**

If the crankshaft is worn excessively at the point where the seal makes contact, the seal may be pressed into the front cover  $\frac{1}{8}$  inch from the outside surface.

*(c)* Remove any excess sealant.

*(d)* Install the pressure regulator valves (para 4-55).

*(e)* Install the oil pump (para 4-54).

*(5) Installation.*

*(a)* Affix a new gasket (3) to the front cover (2).

*(b)* Install an oil seal expander over the end of the crankshaft.

*(c)* Thread two  $\frac{3}{8}$ -16 x 8 inch pilot studs into two diametrically opposite bolt holes in the block to guide the cover in place.

*(d)* Apply a light coat of cup grease to the lip of seal (1).

*(e)* Slide the cover over the seal expander and pilot studs until the inner rotor (10) of the oil pump contacts the pump drive gear (9) on the crankshaft. Rotate the crankshaft as required to align the teeth and push the cover against the block. Do not force the cover.

*(f)* Remove the seal expander and pilot studs.

*(g)* Install the capscrews (17) and lockwashers (16). Torque the capscrews to 30—35 pound-feet torque.

*(h)* Install the oil inlet tube and screen (para 4-42).

*(i)* Install the oil pan (para 4-41).

*(j)* Install the front trunnion mount (para 4-52).

*(k)* Install the crankshaft pulley (para 5-1).

*(l)* Install the fan belts (refer to TM 5-3810-290-12).

**4-54. Oil Pump**

*a. General.* The oil pump is assembled to the inside of the lower engine front cover. The pump is of the rotor type in which the inner rotor is driven by a gear pressed on the front end of the crankshaft. Oil is drawn from the crankcase through the oil pump inlet pipe to the pump inlet ports. Oil is then forced out of the pump under pressure through the discharged port into a passage in the front cover which leads to the oil cooler and filter and is then distributed throughout the engine. Stabilized oil pressure is maintained by means of regulator valve installed in the lower front cover.

*b. Removal.*

*(1)* Remove the lower front cover (para 5-3 c).

*(2)* Remove the six capscrews (14, fig. 4-48) and lockwashers (13) which attach the assembly to the front cover (2). Withdraw pump assembly.

*c. Disassembly.*

*(1)* Remove the drivescrews (15), and remove the cover plate (8) from the pump body (12).

*(2)* Remove the inner (10) and outer (11) rotors from the pump body.

*d. Cleaning, Inspection, and Repair.*

*(1)* Clean all parts with an approved cleaning solvent. Dry with compressed air.

*(2)* Inspect the lobes of the rotors for wear,

scratches, or burrs. Inspect surfaces of housing and cover plate for scratches or scoring. Remove scratches or light scoring with a fine grit abrasive stone.

(3) Inspect the splines of the inner rotor for excessive wear. Replace as necessary.

(4) Measure the clearance between inner and outer rotors at each lobe with a feeler gage (fig. 4-49 a). Replace rotors if listed clearance is exceeded.

(5) Measure clearance from face of pump body to side of inner and outer rotors (fig. 4-49). Replace rotors (matched set) if specified clearance is exceeded.

*e. Assembly.*

(1) Install the outer rotor (11, fig. 4-48) in the pump body (12). Position the inner rotor (10) in the outer rotor.

(2) Install the cover plate (8) and secure with new drive screws (15) to hold the assembly together.

*f. Installation.*

(1) Install the pump assembly in the front cover and secure with capscrews (14) and lockwashers (13). Torque the bolts to 13-17 pound-feet.

(2) Install the lower front cover on the engine (para 4-53).

(3) Install the oil inlet tube and screen (para 4-42).

(4) Install oil pan (para 4-41) and service engine in accordance with current lubrication order.

#### 4-55. Oil Pressure Regulator Valves

*a. General.* The engine is equipped with two pressure regulator valves. The valves are installed in the lower front engine cover, one on each side. The valves stabilize the lubricating oil pressure, regardless of engine speed or oil temperature. The

valves may be removed without removal of the engine assembly from the vehicle.

*b. Removal.* Remove the valve plugs (7, fig. 4-48) springs (5), and valves (4) from the cover (2). Remove and discard gaskets (6).

*c. Cleaning, Inspection, and Repair.*

(1) Clean all parts in an approved cleaning solvent and dry thoroughly.

(2) Inspect the valves (4, fig. 4-48) for scoring or wear.

(3) Inspect the springs (5) for cracks and lack of compression.

**NOTE**

The springs have a free length of approximately 2.25 inches, and require 9½ pounds of pressure to compress them to 2 inches. Replace as required.

*d. Installation.*

(1) Coat the valves (4) with clean engine oil and insert them in the front cover, closed end first.

(2) Install the springs (5), and while compressing with fingers install plugs (7) with new gaskets (6).

Key to figure 4-48.

1. Seal
2. Front cover
3. Gasket
4. Valve (2)
5. Spring (2)
6. Gasket (2)
7. Plug (2)
8. Cover
9. Drive gear
10. Innwe rotor
11. Outer rotor
12. Body
13. Lockwasher (6)
14. Capscrew (6)
15. Drive screw (2)
16. Lockwasher (12)
17. Capscrew (12)

**NOTE:** Items 10 and 11 are a matched set.

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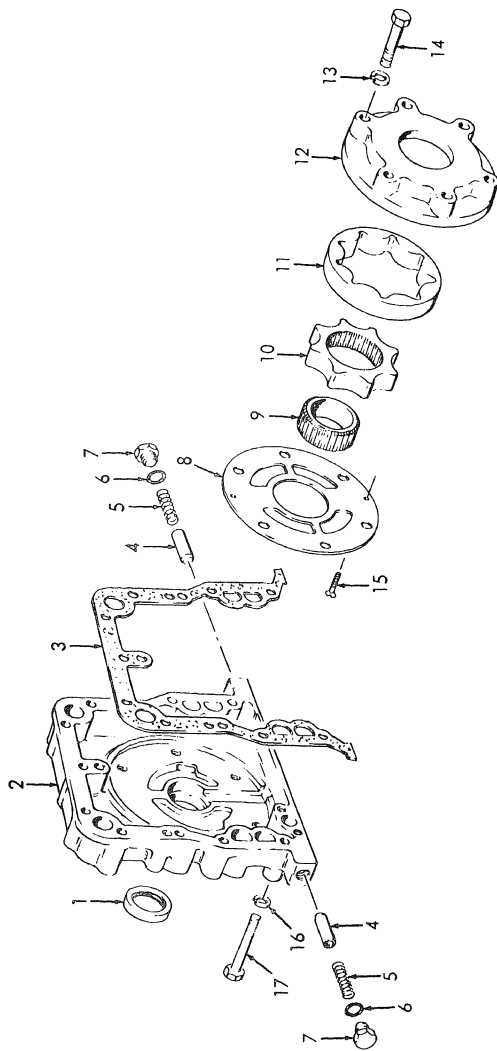


Figure 4-48. Lower front cover and oil pump, exploded view.

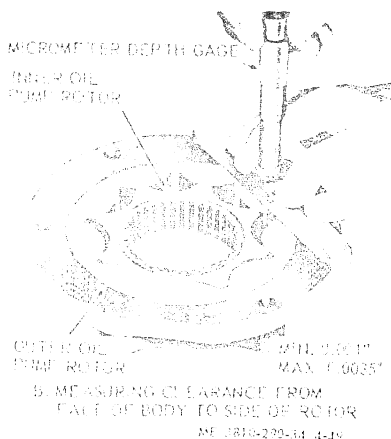
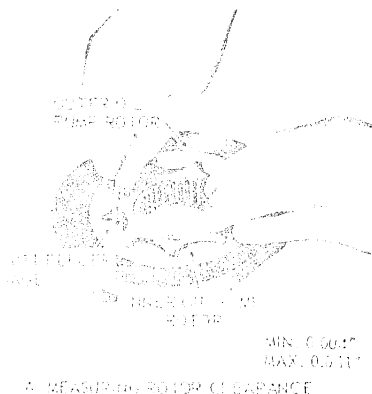


Figure 4-49. Inspecting pump rotors.

## Section XXIV. PISTONS, CONNECTING RODS AND CYLINDER LINERS

### 4-56. Pistons

a. *General.* Malleable iron pistons are connected by piston pins to the upper end of drop-forged, carbon-steel connecting rods. The lower end of the connecting rods are attached to the crankshaft by bearing caps. The extra long piston skirts, accurately ground to full length, are plated with a protective coating of tin, which permits close fitting. Each piston is fitted with six piston rings. Four compression rings are placed above the piston pin, and two three-piece oil control rings are placed below the pin to wipe any excessive lubricating oil being thrown onto the cylinder liners by the crankshaft and the lower end of the connecting rod.

#### NOTE

Cylinder liners, although as a functional group item are considered as a component of the cylinder block, are normally supplied with the piston assembly as matched components.

#### b. Removal.

- (1) Remove the cylinder head (para 4-35).
- (2) Remove the crankcase oil pan (para 4-41).
- (3) Remove the oil inlet tube and screen (para 4-42).

(4) Remove any carbon deposits from upper inner surface of cylinder liner (1, fig. 4-50).

(5) Remove the nuts (11) from the connecting rod bolts (9). Remove the connecting rod bearing cap (12) and lower bearing shell (10) from the connecting rod.

(6) Push the piston and connecting rod assembly through the top of the cylinder block. Repeat the procedure for all pistons and connecting rod assemblies.

#### NOTE

Mark each piston, connecting rod and bearing cap so they may be kept as a set and replaced together.

#### c. Disassembly.

(1) Secure connecting rod in vise with soft jaws.

(2) Remove compression rings (2) with expanding tool.

#### CAUTION

Do not spread the rings more than necessary to remove.

(3) Punch a hole in center of retainer (5) with punch or narrow chisel. Pry retainer from piston.





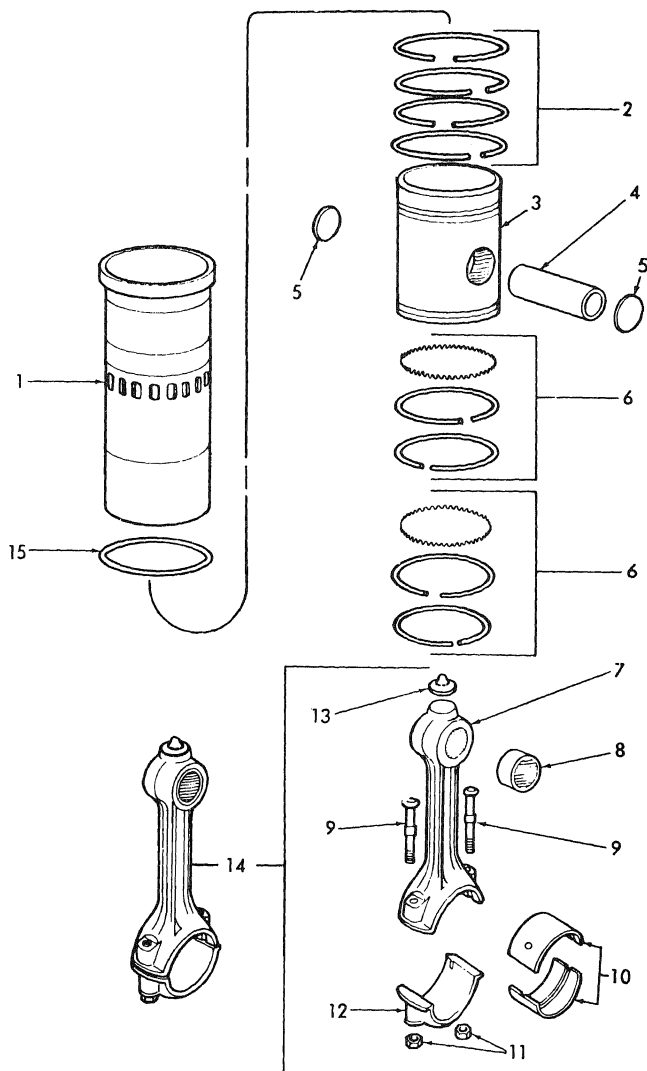


Figure 4-50. Piston and ring assembly, connecting rod, and cylinder liner, exploded view.

1. Cylinder liner (6)\*
2. Ring set (6)\*
3. Piston (6)\*
4. Pin (6)\*
5. Retainer (12)\*
6. Ring set (12)\*
7. Connecting rod (6)\*\*
8. Bushing (12)
9. Bolt (12)
10. Bearing set (6)
11. Nut (12)
12. Bearing cap (6)\*\*
13. Nozzle (6)
14. Connecting rod assembly (6)
15. Seal (6)\*

\* Available in parts kit.

\*\* Not serviced separately.

(4) Remove piston pin (4), freeing piston from connecting rod.

(5) Drive second retainer from piston with brass rod.

(6) Remove oil control rings (6) with ring expander, exercising same caution as noted above.

*d. Cleaning, Inspection, and Repair.*

(1) Clean all parts with an approved cleaning solvent. Dry with compressed air.

(2) Remove carbon deposits from piston with chemical solvent that will not attach tin plating on piston.

(3) Clean piston ring grooves with a suitable tool, such as a broken half of a compression ring sharpened to a bevel edge. Clean cooling surfaces on inside of piston. Thoroughly clean oil return holes in piston skirt probes, being careful not to enlarge holes during cleaning process.

(4) Inspect piston for scoring, burning, worn or damaged ring grooves, and cracks inside piston across struts. A badly scored piston must be replaced. A slightly scored piston may be cleaned

up with crocus cloth or fine stone and reused with cylinder liner if clearances are not exceeded (table 4-6).

(5) Inspect piston for minute cracks.

(6) Inspect top of piston crown for burned spots or other indications of overheating such as carbon formation of underside of piston.

(7) Inspect the ring grooves in the piston and the piston rings for free fit in grooves, side clearance and wear.

**NOTE**

The presence of original grooves on ring surfaces indicates practical absence of wear.

(8) Inspect and measure piston pin bushings and piston for wear. Wear and clearance limits are listed in table 4-6 below. If worn beyond specified tolerances, replace bushings or piston assemblies.

(9) Measure piston diameter and cylinder liner bore with the temperature at 70° F. Take the piston skirt measurement both lengthwise and crosswise of the piston pin; measure the cylinder liner bore, both lengthwise and crosswise of the piston pin, throughout the entire length of the cylinder liner.

(10) The piston should be round with 0.0005 inch. New cylinder liner bores should be round within 0.0001 inch. Measure the clearance of the piston in the cylinder liner bore by placing a ½ inch feeler ribbon, about 15 inches long, between the piston and the liner. Move the feeler ribbon 90° and recheck the clearance. Refer to table 4-6 for standard clearance and allowable wear limits between the cylinder liner and the piston skirt.

(11) If the piston binds in the cylinder liner remove both piston and liner and check dimensions in accordance with table 4-6.

*Table 4-6. Cylinder Liner and Piston Assembly  
Dimensional and Wear Limit Data*

| Component                            | Manufacturers dimensions and tolerances in inches |         | Maximum allowable wear and clearances |
|--------------------------------------|---|---------|---------------------------------------|
|                                      | Minimum   | Maximum |                                       |
| CYLINDER LINER                       |   |         |                                       |
| Outside diameter (seal ring surface) | 4.4850  | 4.4860  |                                       |
| Inside diameter                      | 3.8752  | 3.8767  |                                       |
| Out-of-round                         |   | 0.0020  | 0.003                                 |
| Taper                                |   | 0.0010  | 0.002                                 |
| PISTON                               |   |         |                                       |
| Diameter (at skirt)                  | 3.8693  | 3.8715  |                                       |
| Clearance (piston to liner)          | 0.0037  | 0.0047  | 0.010                                 |
| Out-of-round                         |   | 0.0005  |                                       |
| Taper                                |   | 0.0005  |                                       |
| Bushing, piston pin, inside diameter | 1.3775  | 1.3780  |                                       |
| PISTON PIN                           |   |         |                                       |
| Diameter                             | 1.3746  | 1.3750  |                                       |

**Table 4-6. Cylinder Liner and Piston Assembly  
Dimensional and Wear Limit Data—Continued**

| Component                         | Manufacturers<br>dimensions and<br>tolerances in inches |         | Maximum<br>allowable<br>wear and<br>clearances |
|-----------------------------------|---|---------|--|
|                                   | Minimum   | Maximum |  |
| Clearance (pin to piston bushing) | 0.0025  | 0.0034  | 0.010  |
| Clearance (pin to rod bushing)    | 0.0010  | 0.0019  | 0.010  |
| <b>PISTON RINGS</b>               |   |         |  |
| Gap (17:1 compression)            | 0.0200  | 0.0460  | 0.060  |
| Clearance (tring to groove)       |   |         |  |
| Top (No. 1)                       | 0.0030  | 0.0060  | 0.016  |
| No. 2                             | 0.0070  | 0.0100  | 0.014  |
| No. 3 and 4                       | 0.0050  | 0.0080  | 0.013  |
| Gap (oil rings)                   | 0.0100  | 0.0250  | 0.044  |
| Clearance (tring to groove)       | 0.0015  | 0.0055  | 0.008  |

\* Also applicable to oversize or undersize parts.

#### *e. Assembly.*

- (1) Install new compression rings (2, fig. 4-50) on the piston.

#### **NOTE**

Check the piston ring gap by inserting ring squarely in cylinder liner and measuring gap with feeler gage. The specified gap for compression rings is 0.020—0.046 inch, and oil control rings 0.010—0.025 inch.

#### **CAUTION**

Install the top compression ring with the mark **TOP** toward the top of the piston.

#### **NOTE**

Each ring should have its gap located 45 degrees from the ring gap above it.

- (2) Install new oil control rings (6) on the piston with the scraping edge of the ring down. Install an expander in the upper oil ring grooves. *Do not overlap the ends.* Install the top oil ring, with the gap 180 degrees from the expander ends. Install the bottom oil ring with the gap 45 degrees from the gap in the upper oil ring.

- (3) Install the second set of oil control rings and expander as described above.

- (4) Install the connecting rod (7) in the piston assembly. Insert the piston pin (4) and install new retainers (5).

- (5) Place piston and rod assembly on clean surface with rod end up. Wipe exterior surface of piston clean and dry. Fill inner part of piston with clean fuel oil and allow to remain for 15 minutes to check for possible leakage around retainers. Remove fuel oil and lubricate all external surfaces of piston assembly.

#### *f. Installation.*

- (1) Apply clean engine oil to piston, rings, and inside of ring compressor tool.

- (2) Install the ring compressor tool over the piston and connecting rod assembly so that the small end of compressor is at the bottom of the piston.

- (3) Insert the rod end in the top of installed cylinder liner (1) and position the compressor tool on top of the liner.

#### **CAUTION**

Distances from center of connecting rod bolts to sides of connecting rod are not equal. To avoid cocking the connecting rods must be together when attached to crankshaft journal.

- (4) Push the piston and rod assembly down into the liner until the piston is out of the ring compressor tool. Remove the ring compressor.

- (5) Rotate the crankshaft until the connecting rod journal of the bearing for the respective cylinder is at the bottom of its travel.

- (6) Install lower bearing shell (10) and bearing cap (12), securing with bolts (9) and nuts (11). Torque to 45-50 pound-feet.

- (7) Install the oil inlet tube and screen (para 4-42).

- (8) Install the crankcase oil pan (para 4-41).

- (9) Install the cylinder head (para 4-35).

#### **4-57. Connecting Rods**

##### *a. Removal.*

- (1) Remove the piston and connecting rod assembly (para 4-56).

- (2) Remove the connecting rod from the piston (para 4-56c (3) and (4)).

- (3) Remove the upper bearing shell (10, fig. 4-50) from base of connecting rod.

- (4) Remove spray nozzle (13) and bushings (8) from connecting only if replacement is necessary (para c below).

## NOTE

The upper and lower connecting rod bearing shells may be inspected without removal of the assembly from the cylinder block. Only one bearing cap should be removed at a time. Remove the bearing cap and push the connecting rod and piston assembly up into the cylinder liner enough to clear the crankshaft. Remove the upper bearing shell with a small brass rod and hammer. Do not damage the edge of the shell. Inspect the bearings shells as outlined in "Inspection" below. Replace with new shells as required.

## CAUTION

The upper and lower bearing shells are not interchangeable, and should not be replaced individually.

## b. Cleaning, Inspection, and Repair.

(1) Clean all parts with an approved cleaning solvent. Dry thoroughly with compressed air.

(2) Blow compressed air through the drilled oil passage in the connecting rod (7) to be sure all lubricating passages are cleared.

(3) Inspect the bearing shells for scoring, pitting, flaking, etching and dirt groovings. If any of these defects are noted, replace the bearings.

## NOTE

The upper bearing shells, which carry the load, will normally show signs of wear and/or faults before the lower shells do.

(4) Inspect the backs of the bearing shells for bright spots which indicate they have been moving in their supports. Replace any shells with bright spots.

(5) Inspect the bearing rod bores for burrs, foreign particles, etc.

(6) Inspect the connecting rod bolts (9) for wear or damaged threads. Replace as required.

(7) Measure the thickness of each bearing shell, 90 degrees from the parting line, with a micrometer and ball attachment. The minimum thickness of a worn standard shell is 0.123 inch. If less, replace the shell set.

## NOTE

Undersize bearing shells are available for replacement (table 4-7). The 0.002 inch size is used for slight wear where grinding of crankshaft is not required. The other undersize shells are to be used when the crankshaft journals have been reground to the specified dimensions (table 4-7).

Table 4-7. Crankshaft Journal and Bearing Dimensional Data

| Nominal size of Bearing (inches) | New bearing shell thickness minimum (inches) | Crankshaft connecting rod journal diameters (inches) |
|----------------------------------|--|--|
| Standard                         | 0.1247                                       | 2.749—2.750  |
| 0.002 Undersize                  | 0.1257                                       | 2.747—2.748  |
| 0.010 Undersize                  | 0.1297                                       | * 2.739—2.740  |
| 0.020 Undersize                  | 0.1347                                       | * 2.729—2.730  |
| 0.030 Undersize                  | 0.1397                                       | * 2.719—2.720  |

\*Dimension of reground crankshaft.

(8) Check the clearance between the bearing shells and crankshaft journals with the crankshaft in place, and squeezing a soft plastic measuring strip between the shells and journals with the bearing caps in place, and the nuts (11), torqued to 45-50 pound-feet. Refer to table 4-8 below for tolerances.

(9) Inspect the connecting rod bushings (8, fig. 4-50) for scoring and wear. Replace if either defect is noted. Tolerances between piston pins and bushings are given in table 4-6.

(10) Press out old bushings. Press new bushings into place in connecting rod.

## CAUTION

Bushings should be pressed flush with

edge of connecting rod. This will leave  $\frac{1}{8}$  inch gap between inner edges of bushings for lubrication purposes. New bushings must be reamed to a finished inside diameter of 1.3760-1.3765 inches after installing in the connecting rod.

## c. Installation.

(1) Install the connecting rod in the piston (para 4-56 c) (4) and (5).

(2) Install the piston and connecting rod assembly (para 4-56 f).

## NOTE

If new bearing shells are installed, operate the engine as outlined in the run-in schedule in section XXVII.

Table 4-8. Connecting Rod and Crankshaft Journal  
Dimensional Data and Crankshaft Wear Limit Data

| Item (standard size)              | New Part         |                  | Wear Limits (inches) |
|-----------------------------------|------------------|------------------|----------------------|
|                                   | Minimum (inches) | Maximum (inches) |                      |
| CONNECTING ROD                    |                  |                  |                      |
| Length (center to center)         | 8.7990           | 8.8010           |                      |
| Diameter (lower bore)             | 3.0015           | 3.0025           |                      |
| Diameter (upper bore)             | 1.6000           | 1.6010           |                      |
| Diameter (bushing, inside)        | 1.3760           | 1.3765           |                      |
| Clearance (rod, side, normal)     | 0.0030           | 0.0160           |                      |
| CRANKSHAFT                        |                  |                  |                      |
| Journal Diameter (connecting rod) | 2.7490           | 2.7500           |                      |
| Journal out-of-round              |                  | 0.00025          |                      |
| Journal taper                     |                  | 0.0005           | 0.003                |

#### 4-58. Cylinder Liners

##### a. Removal.

(1) Remove piston and connecting rod assemblies (para 4-56).

(2) Remove liners (1, fig. 4-50) from cylinder block with liner removal tools or tapping the liner out with a hardwood block and hammer.

(3) Remove and discard seal (15).

##### b. Cleaning, Inspection, and Repair.

(1) Remove carbon deposits from cylinder liners with carbon solvent. Clean liners with an approved solvent and dry with compressed air.

(2) Inspect cylinder liner for cracks, scoring, corrosion, and flange irregularities. Replace a cracked, eroded, or badly scored liner.

(3) Install cylinder liner in block and measure liner bore as instructed in paragraph 4-56 d (9). If taper exceeds 0.002 inch, or out-of-round exceeds 0.003 inch, replace the liner.

##### NOTE

Cylinder liners must be installed in their original positions. Aline match marks.

(4) If taper or out-of-round does not exceed specified limits, minor scoring or ridging at top of ring travel may be removed by honing. Use the following procedure when honing cylinder liners.

(a) Place the cylinder in a suitable holding fixture.

(b) Using a hone equipped with 120 grit stones, work the hone up and down the full length of the liner a few times so a "criss-cross" pattern with hone marks on a 45 degree axis will result.

(c) Remove liner from fixture and clean thoroughly.

(d) Check entire surface of liner bore for burrs.

(5) If a new cylinder liner is to be used, install the liner in the block and take measurement as instructed in paragraph 4-56 d, (9). A new cylinder must be 3.8752 to 3.8767 inches on inside diameter, must be straight from top to bottom within 0.001 inch, and round with an 0.002 inch. Refer to table 4-6 for piston to liner clearance.

##### NOTE

Match mark a new liner to its respective block bore.

##### c. Installation.

(1) Apply clean engine oil to piston and rings of piston and connecting rod assembly and the inside of ring compressor tool.

(2) Place ring compressor tool on wood block (tapered end up).

(3) Insert the top of the piston in the ring compressor, and carefully push the piston down until it contacts the wood block.

(4) Wipe the inside and outside of the cylinder liner clean. Also, make sure the block bore and counterbore are clean so the liner flange will seat properly. Place the liner, top down, on a wood block.

(5) Place the ring compressor with piston and connecting rod assembly on the cylinder liner.

(6) Push the piston and rod assembly down into the liner until the piston is out of the ring compressor tool.

(7) Make sure the seal ring groove in the block is clean. Install the seal ring (15). Lubricate seal ring with permanent type antifreeze.

(8) Rotate the crankshaft until the connecting rod journal of the bearing for the respective cylinder is at the bottom of its travel.

(9) Slide cylinder liner with piston and connecting rod assembly into cylinder block bore.

**NOTE**

Aline match marks of cylinder liner and cylinder block while inserting the liner.

(10) Push piston and cylinder liner down and guide connecting rod until upper bearing shell (10),

fig. 4-50 is seated firmly on crankshaft journal, and cylinder liner is flush with top of cylinder block.

(11) Complete installation as instructed by paragraphs 4-56 f(6) through (9).

**Section XXV. CRANKSHAFT AND MAIN BEARINGS****4-59. Crankshaft**

*a. General.* The crankshaft is a one-piece steel forging, heat-treated to ensure strength and durability. All main and connecting rod bearing journal surfaces and oil seal surfaces are induction hardened. Complete static and dynamic balance has been achieved by counterweights.

*b. Removal.*

- (1) Remove lower front cover (para 4-53 c).
- (2) Remove flywheel housing (para 4-44).
- (3) Remove rocker arm covers (para 4-34) and remove fuel oil pipes (fig. 4-36). Install dust caps on injector and fuel connectors.
- (4) Remove bolts (10, fig. 4-34) and pivot the rocker arms away from the valve stems. This step is necessary to prevent damage to valves and valve

stems should a piston assembly be allowed to drop or pushed down on the valves.

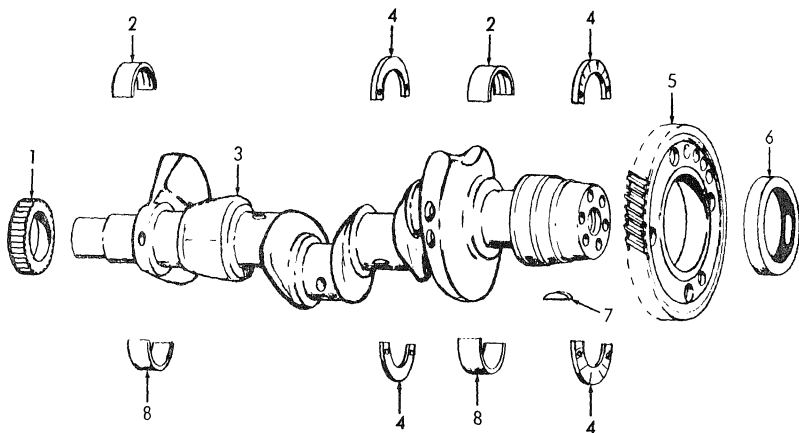
(5) Remove the connecting rod bearing caps (12, fig. 4-50). Push the piston assemblies toward the cylinder head until the connecting rod bolts are clear of the crankshaft.

**NOTE**

It may be necessary to push one of the valves open to expel air from the cylinder chamber when pushing piston into block.

(6) Remove eight bolts (20, fig. 4-54), washers (21), and bolts (19). Lift off stabilizer (18), bearing caps (17), and lower bearing shell (8, fig. 4-51).

(7) Remove thrust washers (4) from each side of rear main bearing.



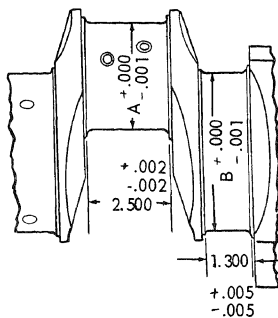
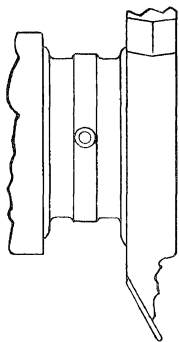
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- |                       |                       |
|-----------------------|-----------------------|
| 1. Gear               | 5. Timing gear        |
| 2. Bearing, upper (4) | 6. Seal               |
| 3. Crankshaft         | 7. Key                |
| 4. Thrust washer (4)  | 8. Bearing, lower (4) |

Figure 4-51. Crankshaft, timing gear and main bearings, exploded view.

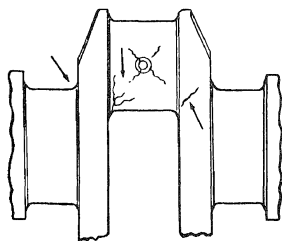


NOTE: ALL DIMENSIONS IN INCHES

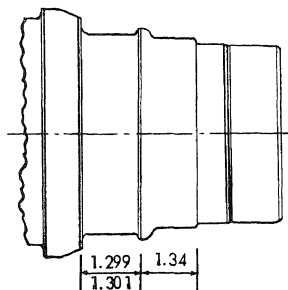


A. TYPICAL RIDGING OF CRANKSHAFT

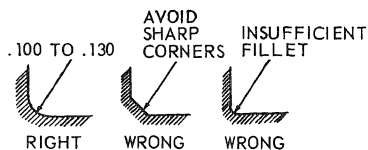
B. DIMENSIONS OF CRANKSHAFT JOURNALS AND CRANK PINS



C. CRANKSHAFT FATIGUE CRACKS



D. DIMENSIONS AT REAR MAIN BEARING THRUST WASHERS



E. CRANKSHAFT JOURNAL FILLETS

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Figure 4-52. Crankshaft inspection details.

(8) Attach a suitable sling to crankshaft (3) and remove from the cylinder block.

(9) Remove the crankshaft timing gear (para 4-51).

(10) If necessary, remove the oil pump drive gear (1, fig. 4-51) as follows:

(a) Thread the crankshaft pulley retaining bolt (1, fig. 4-46) into end of crankshaft to provide a bearing surface for gear puller screw.

(b) Attach a suitable gear puller over gear and end of crankshaft and remove pulley.

*c. Cleaning, Inspection, and Repair.*

(1) Clean the crankshaft with an approved cleaning solvent. Dry thoroughly with compressed air.

(2) Place the crankshaft on a surface plate in V-blocks or in lathe and with a dial indicator, check the dimensions as shown in figure 4-52B and D. If the tolerances specified are exceeded, the crankshaft must be metallized and reground, or replaced with new crankshaft.

(3) Inspect the surfaces of the crankshaft for evidence of cracks (fig. 4-52C). Any signs visible to the eye should justify replacement of the crankshaft.

(4) If one or more journals require grinding, then all journals must be ground to the same dimensions (table 4-9). The grinding operation should not be forced, and grinding coolant used generously to avoid localized heating on the crankshaft. Grind fillets per figure 4-52E.

(5) A slight ridging on journals may be evident on used crankshafts. If this ridging does not exceed 0.0002 inch, remove with fine emery cloth (120 and 240 grit). Polish with crocus cloth moistened in clean fuel oil.

(6) Inspect the thrust washer surfaces of the crankshaft for signs of scoring or wear. Clean lightly scored surfaces with an oil stone. Grind deeply scored surfaces and use oversize thrust washers when assembling to maintain the specified crankshaft end play when installing the crankshaft (table 4-10).

Table 4-9. Crankshaft and Bearing Dimensional Data

| Bearing size (inches) | Conn. rod journal dia. (inches) | Main bearing journal dia. (inches) |
|-----------------------|---------------------------------|------------------------------------|
| Standard              | 2.750                           | 3.500                              |
| 0.002" Undersize      | 2.750                           | 3.500                              |

Table 4-10. Thrust Washer Dimensional Data and Wear Limits

| Nominal Size (inches) | Thrust washer thickness (inches) |         |
|-----------------------|----------------------------------|---------|
|                       | Minimum                          | Maximum |
| 0.005 Oversize        | 0.1255                           | 0.1270  |
| 0.010 Oversize        | 0.1300                           | 0.1320  |

(7) Inspect the oil pump drive gear (1, fig. 4-51) for worn or cracked teeth. Replace as required.

*d. Installation.*

(1) Start the oil pump drive gear (1, fig. 4-51) straight on the shaft. Position drive gear installer tool over gear and force gear on crankshaft until crankshaft end contacts end of bore in tool.

(2) Install the crankshaft timing gear (para 4-49).

(3) If removed or replaced, install the upper main bearing shells (2) in the cylinder block.

(4) Lubricate the crankshaft journals with clean engine oil. Install the crankshaft in the cylinder block, making sure the timing marks on the crankshaft timing gear (5) are aligned with the idler gear (fig. 4-43).

(5) Install the upper thrust washer halves (4, fig. 4-51) on each side of the rear main bearing. Install the doweled lower thrust washer halves on each side of the rear main bearing cap.

(6) Position the lower main bearings (8) in the respective bearing caps (17, fig. 4-54).

(7) Position the bearing caps with bearings on crankshaft and secure with stabilizers (18), bolts (19 and 20), and washers (21). Draw the bolts up snug. Tap the bearing cap lightly with a soft hammer to seat the bearings properly.

(8) Tighten the cap bolts (19) to 120-130 pound-foot torque. Tighten the bolts (20) to 70-75 pound-foot torque.

**NOTE**

If installed properly, the crankshaft will turn freely with the main bearing caps tightened to the above specified torque.

(9) Check the crankshaft end play with a dial indicator placed against the timing gear and shifting the position of the crankshaft with a screwdriver wedged between either side of the rear bearing cap. The end play should be 0.004—0.011 inch with new parts, and not exceed 0.018 inch with used parts. Otherwise, inspect for misaligned

rear main bearing cap, bur or dirt on thrust washer, or incorrect thrust washer thickness.

(10) Pull the pistons and connecting rods up against the crankshaft journals, and install the caps (12, fig. 4-50). Tighten nuts (11) to 50—55 pound-feet torque.

(11) Install flywheel housing, flywheel, and associated components as outlined in paragraph 4-44.

(12) Install the lower front cover and associated components as outlined in paragraph 4-53 c.

(13) Position the rocker arm shafts and brackets properly and secure with bolts (10, fig. 4-34). Tighten bolts to 50—55 pound-feet torque.

#### NOTE

Adjust the valve clearance as outlined in Section XXVII.

(14) Remove the dust caps from injector and fuel connectors and install fuel oil pipes (fig. 4-36).

(15) Install the rocker arm covers (para 4-34).

#### NOTE

If a new crankshaft, or new connecting rod bearing or main bearings are installed, operate as outlined in the run-in schedule (sec. XXVIII).

### 4-60. Main Bearings

a. *General.* The main bearing shells are of the precision type and may be readily replaced without machining. They are used at each crankshaft main journal and consist of an upper shell seated in the cylinder block main bearing support and a lower shell seated in the main bearing cap. Bearing shells are prevented from endwise or radial movement by a tang at the parting line at one end of each shell. The bearing caps are numbered 1, 2, 3, and 4, indicating their respective positions and, when removed, must always be reinstalled in their original positions. Main bearing thrust washers absorb the crankshaft thrust at each side of the rear main bearing. Each washer is made up of two halves, the lower half is doweled to the bearing cap. The upper and lower bearing shells are not interchangeable; the upper bearing shells are grooved, and the lower shells are not. If one bearing shell is to be replaced, all main bearings shells must be replaced.

b. *Removal.* If the crankshaft is removed, as outlined in paragraph 4-59, removal of the main bearing shells (2 and 8, fig. 4-51) is greatly simplified by lifting the bearing shells from their respective bearing caps and bearing supports in the block. If removal of the crankshaft is not required, the bearing shells may be removed in the following manner.

#### NOTE

When using the following method of bearing removal, remove only one main bearing cap at a time, complete inspection and install the bearing shells and cap before removal of the next bearing cap.

(1) Remove the crankcase oil pan (para 4-41).

(2) Remove the oil inlet tube and screen (para 4-42).

(3) Two methods of removal are required, one for the front and intermediate bearings, and a second method for the rear main bearing.

(4) Remove, one at a time, the front and intermediate bearing shells as follows:

(a) Remove bolts (20 and 19, fig. 4-54), washers (21), and stabilizers (18).

(b) Lift off main bearing cap (17) and remove lower bearing shell (8, fig. 4-51).

(c) Insert a special bolt (standard  $\frac{1}{4}$ " x  $\frac{3}{4}$ " long, with head ground to a thickness of  $1\frac{1}{16}$  inch) into crankshaft journal oil hole so that bolt head does not extend beyond the outer surface of the upper bearing shell. Rotate the crankshaft a clockwise direction and roll the upper bearing shell out of the bearing support.

(d) Clean, inspect, and install main bearings (para c and d. below) and repeat procedure for each intermediate bearing.

(5) Remove the rear main bearing shells as follows:

(a) Remove bolts (20 and 19, fig. 4-54), washers (21) and stabilizers (18).

(b) Lift off rear main bearing cap (17) and remove lower thrust washer halves (4, fig. 4-51) and lower bearing shell (8).

(c) Remove upper thrust washer halves (4) by pushing one side with a small rod, forcing washer around and out on opposite side of the journal.

(d) Remove the upper rear main bearing shell by driving on the edge of the shell with a small curved rod, at the same time rotating the crankshaft. This will roll the bearing shell from its position.

#### c. *Cleaning and Inspection.*

#### NOTE

Since the lower main bearing shells carry the crankshaft load, their condition will normally indicate the need for replacement.

(1) Clean the bearing shells with an approved cleaning solvent. Dry thoroughly with compressed air.

(2) Inspect the shells visually for scoring, pitting, flaking, cracking, loss of babbitt, or signs of overheating. If any of these defects are present, the bearings must be replaced.

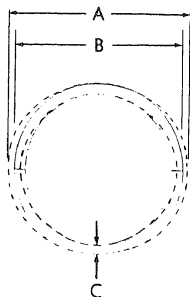
## NOTE

Babbit plated bearings may develop minute cracks or isolated cavities. These are not detrimental to engine operation and are not justification for bearing replacement.

(3) Inspect the backs of the shells for bright spots which indicate they have been moving in the cap or cylinder block. If such spots are present, discard the shells.

(4) Measure the thickness of the shells at point C (fig. 4-53) with a micrometer and ball attachment.

- A. FREE DIAMETER
- B. INSTALLED DIAMETER
- C. BEARING THICKNESS



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Figure 4-53. Main bearing shells, measurement diagram.

(5) The minimum thickness of a worn standard main bearing shell is 0.123 inch. If any of the shells are thinner than this dimension, replace all shells. Table 4-11 lists the minimum bearing shell thickness for new standard and undersize bearings, and the crankshaft main bearing journal diameters corresponding to each bearing size.

(6) Measure the clearance between main bearings and crankshaft journals. If the crankshaft is in place, measure the clearance with a soft plastic measuring strip forced between the journal and bearing. If the clearance is, or exceeds 0.007 inch, replace all bearing shells. With new shells, the clearance should be 0.0025—0.0057 inch.

Table 4-11. Crankshaft Main Journal and Bearing Dimensional Data

| Nominal size of bearing (inches) | Minimum new bearing shell thickness (inches) | Crankshaft main bearing journal diameter (inches) |
|----------------------------------|--|---|
| Standard                         | 0.1240                                       | 3.499—3.500                                       |
| 0.002 Undersize                  | 0.1250                                       | 3.497—3.498                                       |

(7) If the crankshaft is removed, install the bearing shells in the block. Replace bearing caps and torque bearing cap bolts to 120—130 pound-feet. Measure inside diameter of bearings and compare with crankshaft main bearing journal diameters as listed in table 4-11. The tolerances specified in paragraph (6) above apply.

## NOTE

Do not attempt to rework bearing shells. Replace all bearing shells as required. Use undersize bearing shells with crankshafts that have been reground (para 4-59, c (4)).

## d. Installation.

(1) Apply clean engine oil to all crankshaft journals and install the main bearing shells in reverse of removal.

(2) Install new or original upper bearing shells after inspection by rolling into place in the bearing support.

## NOTE

Start the end of shell having no tang around the crankshaft journal first, so that when shell is in place the tang will fit into groove in shell support.

(3) Install the upper thrust washers (4, fig. 4-51).

(4) Position the lower bearing shell and the lower thrust washer halves (on rear bearing cap only) in bearing caps and install over crankshaft journals.

(5) Secure bearing caps with stabilizers (18, Fig. 4-54), washers (21) and bolts (19 and 20). Tighten bolts (19) to 120—130 pound-feet torque and bolts (20) to 70—75 pound-feet torque.

## NOTE

If the main bearings have been installed properly, the crankshaft will turn freely.

(6) Check crankshaft end play (para 4-59 d (9)).

(7) Install the oil inlet tube and screen (para 4-42).

(8) Install the crankcase oil pan (para 4-41).

## Section XXVI. END PLATE AND CYLINDER BLOCK

### 4-61. Rear End Plate

*a. General.* The rear end plate is a flat steel plate, bolted to the rear end of the cylinder block to provide a means of attaching the flywheel housing. Removal of the rear end plate is required only at time of complete engine overhaul.

#### *b. Removal.*

- (1) Remove flywheel housing (para 4-44).
- (2) Remove the idler gear assembly (para 4-48).
- (3) Remove the accessory drive gear (para 4-50).
- (4) Remove the camshaft gears (para 4-46).
- (5) Remove capscrow (13, fig. 4-54) and washer (12).
- (6) Remove twelve capscrows (11), lock washers (10), and washers (9).
- (7) Remove end plate (8) and gasket (7). Discard gasket.

#### *c. Cleaning, Inspection and Repair.*

- (1) Clean the rear end plate with an approved cleaning solvent and dry thoroughly.
- (2) Inspect the end plate for nicks, dents, scratches or scoring. Remove minor scratches and scoring with fine crocus cloth. Replace a badly damaged end plate.

#### *d. Installation.*

- (1) Install the end plate (8) in the reverse order of removal.
- (2) Install washer (12) and capscrow (13) in hole opposite the accessory drive mounting hole. Torque the capscrow to 71—75 pound-feet torque.
- (3) Torque capscrows (11) to 30—35 pound-feet torque.

- (4) Install the camshaft gears, accessory drive gear, idler gear assembly, and flywheel housing in reverse order of removal.

### 4-62. Cylinder Block

*a. General.* The cylinder block is a one-piece casting which forms the main structural part of the engine. Transverse webs provide rigidity and strength and ensure alignment of the block bores and bearings under load. The block is bored to receive replaceable wet type cylinder liners. The camshaft bores are located on the inner side of each cylinder bank, near the top of the block. Drilled passages in the block carry the lubricating oil to all moving parts. Air box openings in both sides of the block permit access to the air box for inspection the pistons and rings through the air inlet port. The top surface of each cylinder bank is grooved to accommodate a block-to-head seal ring. Each water or oil hole is counterbored to provide for individual seal rings. In addition, the block is grooved around the air inlet opening, between the cylinder banks, to accommodate a blower-to-block seal ring.

*b. Removal.* Removal of the cylinder block for replacement or overhaul requires the removal of all engine accessories, sub-assemblies, and components covered in Sections III through XXV of this chapter.

#### *c. Disassembly.*

- (1) Remove the rear end plate (para 4-61).
- (2) Remove air box drain tubes (22, fig. 4-54) and elbows (34) from each side of the cylinder block.

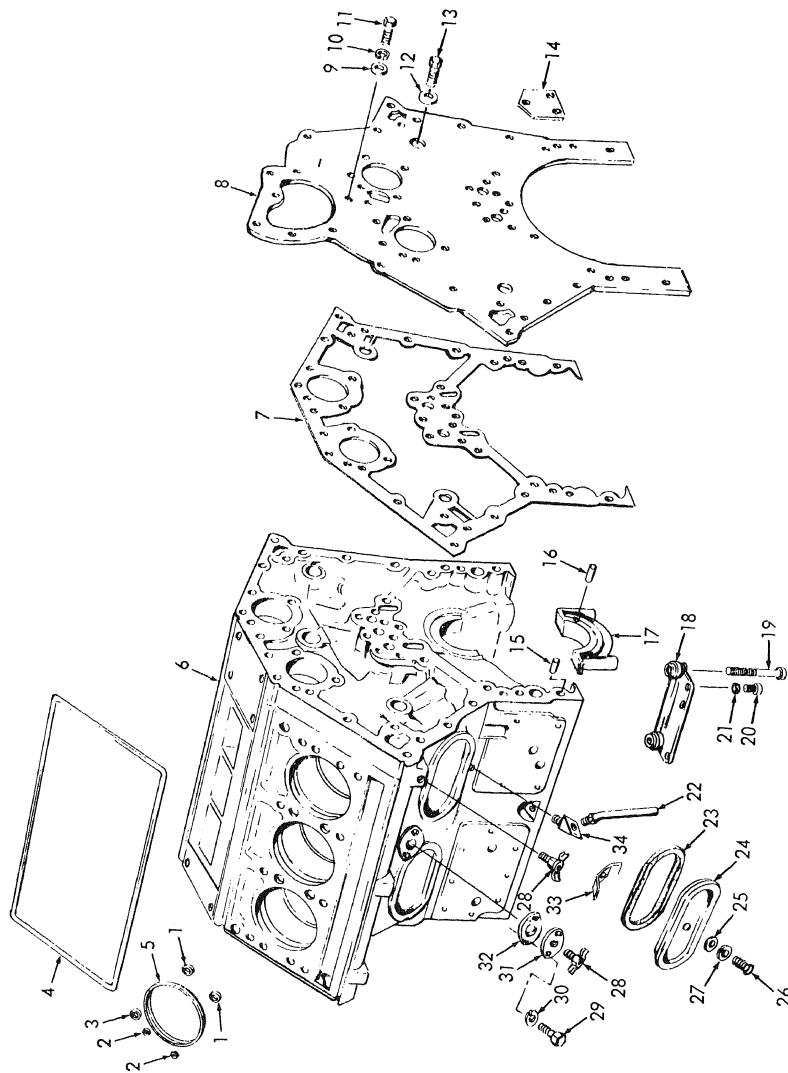


Figure 4-54. Cylinder block, exploded view.

KEY to figure 4-54.

1. Seal ring (4)\*
2. Seal ring (8)\*
3. Seal ring (8)\*
4. Seal ring (2)\*
5. Gasket (6)
6. Block assembly
7. Gasket \*\*
8. End plate
9. Washer
10. Washer (12)
11. Capscrew (12)
12. Washer
13. Capscrew
14. Shim
15. Pin
16. Pin
17. Cap (4)
18. Stabilizer (6)
19. Bolt (8)
20. Bolt
21. Washer (8)
22. Tube (2)
23. Gasket (4)\*\*
24. Cover (4)
25. Gasket (4)\*\*
26. Capscrew (4)
27. Washer (4)
28. Drain cock (2)
29. Bolt (2)
30. Lockwasher (2)
31. Cover
32. Gasket\*\*
33. Clamp (4)
34. Elbow (2)

\* Available in cylinder head gasket kit

\*\* Available in parts kit.

(3) Remove drain cocks (28), bolts (29), lockwashers (30), water hole cover (31), and gasket (32).

(4) Remove four bolts (26), washers (27), gaskets (25), covers (24), gaskets (23), and clamps (33).

(5) Record location and remove various plugs as necessary to thoroughly clean oil galleries and water passageways.

#### d. Cleaning.

(1) Remove all traces of gasket material from the block.

(2) Thoroughly clean cylinder and crankcase oil passages using compressed air and brass wire probes. Flush cylinder and crankcase water jacket thoroughly. Clean block with live steam. Make sure oil galleries, air box floor, and air box drain openings are thoroughly cleaned. Jets machined in camshaft bushing bores permit oil to be sprayed on cam followers; make sure they are not plugged. A 0.020 inch wire may be used to clean jets.

(3) Dry block with compressed air.

#### e. Pressure Testing Block.

(1) To perform pressure test, it will be necessary to make a steel plate of  $\frac{1}{2}$  inch stock to cover each cylinder bank of block. Plates will adequately seal top surface of block when used with cylinder liner compression gaskets and water hole seal rings. It will also be necessary to use water hole cover plates and gaskets to seal water inlet openings in sides of block. One cover plate should be drilled and tapped to provide a connection for an air line so the water jacket can be pressurized.

(2) Make sure seal ring grooves in cylinder bores are clean. Install new seal rings in grooves (above air inlet ports).

(3) Apply a light coating of permanent type antifreeze solution to seal.

(4) Slide cylinder liners into block, being careful not to roll or damage seal rings. Install new compression gaskets and water hole seal rings in counterbores in the top surface of block.

(5) Place plates on top of block and tighten securely with bolts and flat washers.

(6) Install water hole cover plates and gaskets, and cylinder block plugs which were removed during disassembly, on sides of the block.

(7) Immerse the block for twenty minutes in a tank of water which is heated to 180°—200°F.

(8) Attach air line to water hole cover plate and apply 80—100 pounds per square inch air pressure to water jackets and observe water in tank for bubbles which will indicate cracks or leaks.

(9) Remove block from water tank. Remove plates, seals, gaskets, and liners and blow out all passages in block with compressed air.

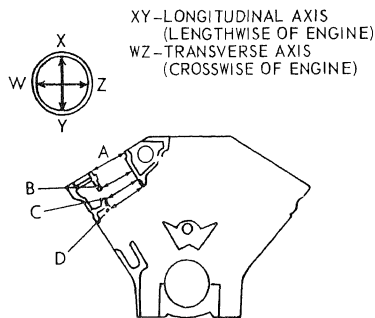
(10) Dry cylinder liners with compressed air and coat with engine oil to prevent rust.

#### f. Inspection and Repair.

(1) Check top machined surfaces of block for flatness with an accurate straight edge and a feeler gage. Surfaces must not vary more than 0.003 inch transversely, and not over 0.006 inch longitudinally.

(2) Make sure seal ring grooves are thoroughly clean. Inspect grooves and lands for evidence of pitting and erosion. If both grooves are eroded to extent that sealing is affected, block must be replaced.

(3) Measure each cylinder block cylinder bore, at positions on axes 90 degrees apart (fig. 4-55). If diameter does not exceed 4.5235 inches at position "A", 4.4900 inches at position "B" (and a sealing problem has not occurred), or 4.3595 inches at position "C" and "D", block may be reused. Taper and out-of-round must not exceed 0.0015 inch.



MEASURE INSIDE DIAMETER OF BLOCK BORE AT PLACES A, B, C, AND D, ON XY AND WZ AXIS.

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Figure 4-55. Cylinder block cylinder bore measurement diagram.

(4) Lubricate threads and underside of each 9 / 16 x 6 main bearing cap bolt head with OE-30 engine oil. Install four main bearing caps, using main bearing bolts with temporary spacers, and tighten bolts to 120-130 pound-feet torque.

(5) Measure main bearing bores. Bearing bores must be 3.751 inches to 3.752 inches. If bores do not fall within these limits, discard block.

(6) Check main bearing bores for alinement. Bearing bores may be considered properly alined with one another if a crankshaft with standard size journals can be rotated freely by hand, after new main bearing shells have been installed and lubricated, and bearing caps have been secured.

(7) Make sure cylinder liner counterbores in block are clean. Check counterbore depth. Depth must be from 0.300 inch to 0.302 inch and must not vary more than 0.001 inch throughout entire circumference. Counterbored surfaces must be smooth and square with cylinder bore within 0.001 total indicator reading.

(8) Check all machined surfaces and threaded holes in block. Remove nicks and burs from machined surfaces with a fine mill file. Clean-up damaged threads in tapped holes with proper tap or install helical thread inserts if threads cannot be cleaned-up.

(9) Replace loose or damaged dowel pins.

(10) Install all required plugs. Use a sealing compound on threads of plugs. If a new service block is used, make sure top surface is plugged correctly to prevent low oil pressure of accumulation of abnormal quantities of oil in cylinder head.

(11) If a new service replacement block is used, stamp unit serial number and model number on top right-hand corner of new block. Make sure bearing caps are properly numbered.

(12) After inspection, if cylinder block is not to be used immediately, spray machined surfaces with OE-10 engine oil. If cylinder block is to be stored for an extended period of time, spray or dip block in a polar-type rust preventive compound.

#### *g. Assembly.*

(1) Clean all oil or rust preventive from the block.

(2) Assemble the cylinder block components in the reverse order of disassembly using new gaskets and seals.

*h. Installation.* Install all engine sub-assemblies and accessories in the reverse order of removal.

#### NOTE

After overhaul of cylinder block, operate the engine as outlined in the run-in schedule in Section XXVII.

## Section XXVII. TESTS, ADJUSTMENTS, AND RUN-IN PROCEDURES

### 4-63. Engine Preparation

*a. General.* A complete overhaul or any major repair job involving the installation of piston rings, pistons, cylinder liners, or bearings will require a run-in period, and various tests and adjustments to

instructions for tests, adjustments, and run-in procedures.

#### *b. Preparation.*

(1) Refer to TM 5-3810-290-12 for services to be performed before starting the engine.



#### 4-64. Tests and Adjustments

*a. Intervals.* Approximately one week after the initial operation of the engine, or following an engine overhaul, the adjustments specified in paragraph *b* below, must be performed. Subsequent intervals for adjustments will be controlled by engine performance, or as may be specified in preventive maintenance services contained in this manual.

*b. Adjustment Sequence.* Normally, when performing adjustments on an engine in service, it is only necessary to check various settings for possible changes in previous adjustment. However, if the cylinder head, governor, or fuel injectors have been removed and overhauled or replaced, then specific preliminary adjustments are required before the engine is started. The preliminary adjustments consist of the first four items in the following sequence. The remaining four items complete the list of engine adjustments to be performed.

- (1) Exhaust valve clearance adjustment (para 4-65).
- (2) Fuel injector timing (para 4-66).
- (3) Governor gap adjustment (para 4-67 *b*).
- (4) Fuel injector rack control level adjustment (para 4-67 *c*).
- (5) Maximum no-load speed adjustment (para 4-67 *d*).
- (6) Idle speed adjustment (para 4-67 *e*).
- (7) Governor buffer screw adjustment (para 4-67 *f*).
- (8) Throttle booster spring adjustment (para 4-67 *g*).

#### 4-65. Exhaust Valve Clearance Adjustment

##### *a. General.*

(1) The correct exhaust valve clearance at normal engine operating temperature is important for smooth, efficient operation of the engine.

(2) Insufficient valve clearance can result in loss of compression, misfiring cylinders, and eventually burned valve seats and valve seat inserts. Excessive valve clearance will result in noisy operation, especially in the low speed range.

(3) Whenever the cylinder head is overhauled, the exhaust valves are reconditioned or replaced, or the valve operating mechanism is replaced or disturbed in any way, the valve clearance must first be adjusted to the cold setting to allow for normal expansion of the engine parts during the engine warm-up period. This will ensure a valve setting which is close enough to the specified clearance to prevent damage to the valves when the engine is started.

- (4) All of the exhaust valves may be adjusted,

in firing order sequence, during one full revolution of the crankshaft.

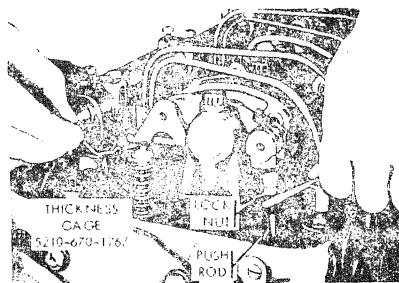
##### *b. Exhaust Valve Clearance Adjustment (Cold Engine).*

- (1) Clean the loose dirt from the exterior of the engine and remove the valve rocker cover(s) (para 4-34).
- (2) Place the governor speed control lever in the idle speed position. Secure the stop lever in the no-fuel position (fig. 4-58A).
- (3) Rotate the crankshaft until the injector follower is fully depressed on the cylinder to be adjusted.

##### CAUTION

If a wrench is used on the crankshaft bolt, do not turn the engine in a left-hand direction of rotation or the bolt will be loosened.

- (4) Loosen the push rod lock nut (fig. 4-56).
- (5) Place a 0.027 feeler gage between the end of one valve stem and the rocker arm bridge (fig. 4-56). Adjust the push rod to obtain a smooth pull the feeler gage.



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Figure 4-56. Exhaust valve adjusting points.

- (6) Remove the feeler gage. Hold with a 5/16 inch wrench and tighten with a 1/2 inch wrench.
- (7) Recheck the clearance. At this time, if the adjustment is correct, the 0.025" gage will pass freely between the end of one valve stem and the rocker arm bridge, and the 0.027" gage will not pass through. Readjust the push rod, if necessary.

##### *c. Exhaust Valve Clearance Adjustment (Hot Engine).*

- (1) Maintaining normal engine operating temperature is particularly important when making the final valve clearance adjustment. If the engine is allowed to cool off before setting any of the

valves, the clearance, when running at full load, may become insufficient.

(2) With the engine at normal operating temperature (160°—185°F.), recheck the exhaust valve clearance with a feeler gage. At this time, if the valve clearance is correct, the 0.23" gage should pass freely between the end of one valve stem and the rocker arm bridge and the 0.25" feeler gage should not. Readjust the push rod, if necessary.

(3) Use new gaskets when installing the valve rocker cover(s) (para 4-34).

#### 4-66. Fuel Injector Timing

##### a. General.

(1) To time a fuel injector properly, the injector follower must be adjusted to a definite height in relation to the injector body.

(2) All of the injectors can be timed, in firing order sequence, during one full revolution of the crankshaft.

##### b. Time Fuel Injector.

(1) Clean the loose dirt from the exterior of the engine and remove the valve rocker (cover(s)) (para 4-34A).

(2) Place the governor speed control lever in the idle speed position. Secure the stop lever in the no-fuel position (fig. 4-58A).

(3) Rotate the crankshaft, manually or with the starting motor, until the exhaust valves are fully depressed on the particular cylinder to be timed.

#### CAUTION

If a wrench is used on the crankshaft bolt at the front of the engine, do not turn the crankshaft in a left-hand direction of rotation or the bolt will be loosened.

(4) Place the small end of the injector timing gage in the hole provided in the top of the injector body, with the flat of the gage toward the injector follower as shown in fig. 4-57.

(5) Loosen the push rod lock nut (fig. 4-57).

(6) Turn the push rod and adjust the injector rocker arm until the extended part of the gage will just pass over the top of the injector followers.

(7) Hold the push rod and tighten the lock nut. Check the adjustment and readjust, if necessary.

(8) Time the remaining injectors as outlined above.

(9) Use new gaskets when installing the valve rocker cover(s) (para 4-34).



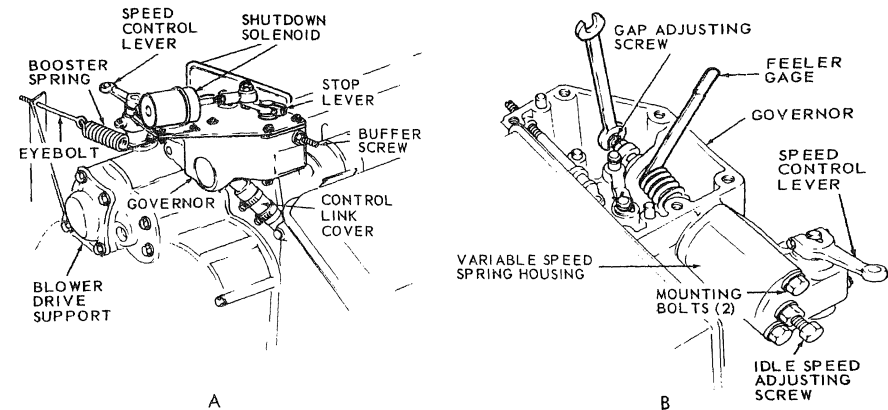
Figure 4-57. Fuel injector timing adjustment points.

#### 4-67. Variable Speed Mechanical Governor and Injector Rack Control Adjustment

##### a. General.

(1) The variable speed mechanical governor assembly is mounted at the rear of the 6V engine, between the flywheel housing and the blower (fig. 4-58). The governor is driven by the right-hand blower rotor drive gear.

(2) After adjusting the exhaust valves and timing the fuel injectors, adjust the governor and the injector rack control levers.



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Figure 4-58. Governor adjustment points.

### b. Adjust Governor Gap.

#### NOTE

The engine must be stopped to adjust the governor gap.

(1) Disconnect any linkage attached to the governor levers (fig. 4-58A).

(2) Remove the governor cover.

(3) Place the speed control lever (fig. 4-58A) in the maximum speed position (toward front of engine).

(4) Insert a 0.006 inch feeler gage between the spring plunger and the plunger guide as shown in fig. 4-58B. If required, loosen the lock nut and turn the adjusting screw in or out until a slight drag is noted on the feeler gage.

(5) Hold the adjusting screw and tighten the locknut. Check the gap and readjust if necessary.

(6) Install the governor cover.

#### c. Position Injector Rack Control Levers.

(1) *Injector control rack positioning and identification.*

(a) The position of the injector control racks must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load.

(b) The letters R or L indicate the injector location in the right or left cylinder bank, viewed from the rear of the engine. Cylinders are numbered starting at the front of the engine on each

cylinder bank. Adjust the No. 3L injector rack control lever first to establish a guide for adjusting the remaining levers.

(2) Loosen the lock nut and back out the buffer screw (fig. 4-58A) approximately  $\frac{3}{4}$ ".

(3) Remove the rocker arm covers (para 4-34).

(4) Remove the clevis pin from the fuel rod and the right cylinder bank injector control tube lever.

(5) Loosen all of the inner and outer injector rack control lever adjusting screws (fig. 4-59B) on both injector control tubes. Be sure all of the injector rack control levers are free on the injector control tubes.

(6) Move the speed control lever to the maximum speed position.

(7) Move the stop lever to the RUN position and hold it in that position with light finger pressure. Turn the inner adjusting screw of the No 3L injector rack control lever down (fig. 4-59A) until a slight movement of the control tube is observed, or step up in effort to turn the screw driver is noted. This will place the No. 3L injector rack in the full-fuel position. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then, alternately tighten both the inner and outer adjusting screws.

(8) To be sure the control lever is properly adjusted, hold the stop lever in the RUN position

and press down on the injector rack with a screwdriver (fig. 4-59B), or finger tip causing the rack to rotate slightly. The setting is sufficiently tight if the rack returns to its original position. If the rack does not return to its original position, it is too loose. To correct this condition, back off the outer adjusting screw slightly and tighten the inner adjusting screw. The setting is too tight if, when moving the stop lever from the STOP to the RUN position, the injector rack becomes tight before the governor stop lever reaches the end of its travel. This will result in a step-up in effort required to move the stop lever to the RUN position and a deflection in the fuel rod (fuel rod deflection can be seen at the band). If the rack is found to be too tight, back off the inner adjusting screw slightly and tighten the outer adjusting screw.

(9) Remove the clevis pin from the fuel rod and the left bank injector control tube lever.

(10) Insert the clevis pin in the fuel rod and the right cylinder bank injector control tube lever and position the No. 3R injector rack control lever as previously outlined in Step (7) for the No. 3L control lever.

(11) Insert the clevis pin in the fuel rod and the left bank injector control tube lever. Repeat the check on the 3L and 3R injector rack control levers

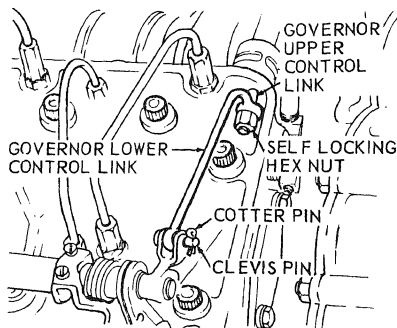
as outlined in Step (8). Check for and eliminate any deflection which may occur at the bend in the fuel rod where it enters the cylinder head.

(12) Manually hold the No. 3L injector rack in the full-position, with the lever on the injector control tube, and turn the inner adjusting screw of the No. 2L injector rack control lever down until the injector rack of No. 2L injector has moved into the full-fuel position. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws.

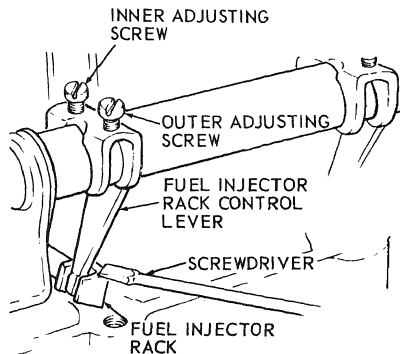
(13) Recheck the No. 3L injector rack to be sure that it has remained snug on the ball end of the rack control lever while positioning the No. 2L injector rack. If the rack of the No. 3L injector has become loose, back off the inner adjusting screw slightly on No. 2L injector rack control lever and tighten the outer adjusting screw. When the settings are correct, the racks of both injectors must be snug on the ball end of their respective control levers.

(14) Position the 1L injector rack control lever as outlined in Steps (12) and (13).

(15) Position the No. 2R and 1R injector rack control levers as outlined above for the left cylinder bank in steps (12) through (14).



A



B

*d. Adjust Maximum No-Load Speed:*

(1) Start engine and operate until normal operating temperature of 160° to 185°F is reached. Remove any load which may have been applied to engine to assist in warming up.

(2) Place governor speed control lever in maximum speed position and measure engine revolutions per minute.

(3) Stop engine and, if engine no-load speed measured above is less than 2650 or more than 2800 revolutions per minute, adjust no-load speed as follows:

(a) Refer to figure 4-58A and disconnect the booster spring and the stop lever retracting spring.

(b) Remove the two attaching bolts and withdraw the variable speed spring housing (fig. 4-58B), and the variable speed spring retainer located inside the housing.

(c) Install one 0.010 inch thick shim for each increase of 20 revolutions per minute required to bring engine speed to range of 2650 to 2800 revolutions per minute.

(d) Remove one 0.010 inch thick shim for each decrease of 20 revolutions per minute required to bring engine speed, above, within range of 2650 to 2800 revolutions per minute.

(e) Install the variable speed spring housing and recheck the maximum no-load speed.

NOTE

If the maximum no-load speed is raised or lowered more than 50 rpm by the installation or removal of shims, recheck the governor gap. If adjustment of the governor gap is required, the position of the injector racks must be rechecked.

*e. Adjust Idle Speed.*

NOTE

The maximum no-load speed must be adjusted before adjusting the idle speed.

(1) Start engine and operate until normal operating temperature of 160° to 185°F is reached. Remove any load which may have been applied to engine to assist in warming up.

(2) Place governor speed control lever in idle speed position and measure engine revolutions per minute.

(3) If engine idle speed is less than 500 or more than 550 revolutions per minute, adjust idle speed as follows:

(a) Loosen idle speed adjusting screw locknut (fig. 4-58B).

(b) Adjust engine idle speed by turning idle speed adjusting screw until engine speed is in range of 500 to 550 revolutions per minute.

(c) Hold idle speed adjusting screw

stationary and securely tighten idle speed adjusting screw locknut.

*f. Adjust Buffer Screw.*

(1) Place governor speed control lever in idle position and loosen governor buffer screw lock nut (fig. 4-58B).

(2) Tighten governor buffer screw until fluctuations in engine idle speed have been eliminated. Hold governor buffer screw stationary and securely tighten locknut.

(3) Measure engine revolutions per minute.

(4) If engine speed has increased by more than 15 revolutions per minute from idle speed, readjust engine idler as follows:

(a) Loosen governor buffer screw lock nut and loosen governor buffer screw until it projects 9/16 to 5/8 inch from surface of governor housing.

(b) Adjust engine idle speed (para c above) to value measured or to 550 revolutions per minute, whichever is lesser value.

(5) Adjust governor buffer screw (steps 1 through 3) above).

(6) If engine idle speed has increased to more than 550 revolutions per minute, one or more fuel injector rack control levers is out of adjustment. Perform fuel injector rack control lever adjustment, maximum no-load speed adjustment, idle speed adjustment, and governor buffer screw adjustment.

(7) If engine idle speed is within 500 to 550 revolutions per minute, place governor speed control lever in maximum speed position and measure engine revolutions per minute.

(8) If engine maximum no-load speed has increased more than 25 revolutions per minute from speed measure, loosen governor buffer screw 1/8 turn.

(9) Hold governor buffer screw stationary and securely tighten locknut.

*g. Adjust Booster Spring.*

(1) Refer to figure 4-58B and loosen the booster spring retaining nut on the speed control lever. Loosen the lock nuts on the eye bolt at the other end of the spring.

(2) Move the spring retaining bolt in the slot of the speed control lever until the center of the bolt is on an imaginary line through the center of the bolt, lever shaft, and eye bolt. Hold the bolt and tighten the locknut.

(3) Start the engine and move the speed control lever to the maximum speed position and release it. The speed control lever should return to the idle position. If it does not, reduce the tension on booster spring. If the lever does return to the idle

position, continue to increase the spring tension until the point is reached that it will not return to idle. Then, reduce the tension until it does return to idle and tighten the locknut on the eye bolt. This setting will result in the minimum force required to operate the speed control lever.

(4) Connect the throttle control linkage to the governor levers.

#### *b. Adjust Engine Load Limiting Device.*

(1) Engines are equipped with a load limiting device on each cylinder block. Refer to figure 4-60 and determine that counterbores in the adjusting screw plate are up and the rocker arm shaft bracket bolts, which fasten the adjusting screw plate to the bracket, are torqued to 50–55 pound-feet (wet torque).

(2) Loosen load limit screw locknut.

(3) Back the load limit screw out of the adjusting screw plate until approximately 1 inch of the screw is below the plate.

(4) Adjust the load limit screw and locknut so the bottom of the locknut is  $7/8$  inch from the bottom of the load limit screw, for the initial setting.

(5) Loosen the load limit lever clamp bolts so the lever is free to turn on the injector rack control tube.

(6) Thread the load limit screw into the adjusting screw plate until the locknut bottoms against the top of the plate.

(7) Hold the injector rack control tube in the full fuel position and place the load limit lever against the bottom of the load limit screw. Tighten the load limit lever clamp nuts to 50–55 pound-feet (wet torque).

(8) Check to insure that injector racks will just go into the full-fuel position; readjust the load limit lever if necessary.

(9) Hold the load limit screw to keep it from turning, then set the locknut until the distance between the bottom of the locknut and the top of the adjusting screw plate is 0.252 inches (6 full turns of the nut) for N-50 injectors or 0.336 inches (8 full turns of the nut) for S-50 injectors.

(10) Thread the load limit screw into the plate until the locknut bottoms against the top of the plate.

#### **NOTE**

Each full turn of the adjusting screw equals 0.042 inches or 0.097 for each flat on the hexagon head.

(11) Hold the load limit screw to keep it from turning, then tighten the locknut to secure the setting.



*Figure 4-60 Engine load limiting device.*

#### **4-68. Cylinder Compression Check**

*a.* Start engine and operate until normal operating temperature of 180° to 185°F. is reached.

*b.* Stop engine and remove rocker arm covers and gaskets (para 4-34).

*c.* Remove fuel inlet and fuel outlet tubes from No. 2L fuel injector.

*d.* Install a suitable jumper connection from No. 2L fuel injector fuel supply port to No. 2L fuel injector fuel return port.

*e.* Remove No. 2L fuel injector (para 4-40).

f. Install an adapter in place of No. 21, fuel injector.

g. Connect pressure gage (0-600 psi) to adapter.

h. Start engine and operate to 600 revolutions per minute.

i. Observe and record compression pressure indicated on gage.

j. Stop engine and remove pressure gage.

k. Remove adapter and jumper connection.

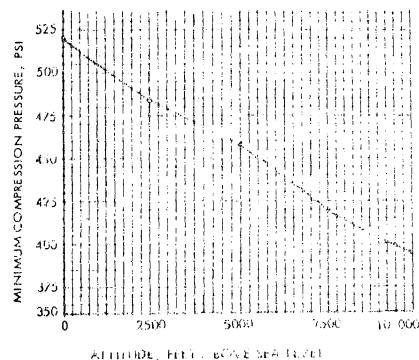
l. Install No. 21, fuel injector and fuel inlet and outlet tubes.

m. Measure cylinder compression pressure of each remaining cylinder in same manner.

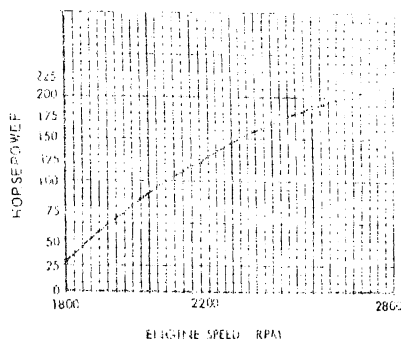
n. Cylinder compression pressure of any one cylinder must be not less than that at indicated altitude (fig. 4-61A).

o. The difference between highest and lowest cylinder compression pressure must be not more than 25 pounds per square inch.

p. If requirements of paragraphs 4-69 and 4-70 are not met, refer to troubleshooting procedure (sec. 11, chap. 2).



A



B

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Figure 4-61. Engine compression and performance charts

#### 4-69. Fuel Flow Test

a. Connect a suitable flexible tube to fuel return line at left rear of engine of sufficient length to conveniently reach a bucket or other suitable container of approximately one gallon capacity.

b. Start and operate engine at approximately 1200 revolutions per minute.

c. Collect fuel flowing from flexible tube in container for a period of one minute, using a suitable timer to establish time interval.

d. Stop engine and measure volume of fuel collected.

e. Volume of fuel measured must be not less than  $\frac{1}{2}$  gallon.

f. If less than  $\frac{1}{2}$  gallon of fuel is measured, refer to troubleshooting (sec. 11, chap. 2).

g. Disconnect flexible hose.

#### 4-70. Fuel Pressure Test

a. Remove left crank-arm cover and gasket (para 4-34).

b. Remove fuel inlet tube to No. 21 fuel injector and install fuel pressure gage between fuel supply connection and injector.

c. Start engine and operate at 2500 revolution per minute.

d. Measure fuel pressure as indicated on fuel pressure gage.

e. Fuel pressure measured must be not less than 35 pounds per square inch.

NOTE:

Normal fuel pressure is 40 to 45 psi at an engine speed of 2500 rpm.

f. If requirement is not met, refer to troubleshooting (sec. 11, chap. 2).

#### 4-71. Crankcase Pressure Test

a. General. The crankcase pressure measures the amount of oil that has passed between the piston and control rings and the cylinder liner into the crankcase, most of which is clean air from the oil box.

oil through the breather tube or liquid level gauge rod-cap hole in the cylinder block indicates excessive crankcase pressure. The causes of high crankcase pressure may be traced to excessive blow-by due to worn piston rings, a hole or a crack in a piston crown, loose piston pin retainers, worn blower oil seals, or defective blower, cylinder head or end plate gaskets. Obstructions in the breather tube may also cause the high crankcase pressure.

*b. Preparation for Test.*

(1) Remove one of two tube connector assemblies from manometer by rotating connector in a counterclockwise direction.

(2) Tighten remaining manometer tube connector assembly by hand, turning in a clockwise direction. Loosen tube connector one full turn.

(3) Add five drops of dye to one pint of distilled water and mix.

(4) Add enough solution prepared to manometer so that liquid level is approximately opposite zero mark on manometer scale when manometer is held in a vertical position.

(5) Install tube connector removed above and adjust per step (2) above.

(6) Remove oil level gage rod-cap from engine oil gage tube.

(7) Install a suitable adapter in oil gage tube and connect hose to adapter and to one of the manometer tube connector assemblies.

(8) Mount manometer in a vertical position and adjust scale so that zero mark is opposite liquid level.

*c. Crankcase Pressure Test Procedure*

(1) Close manometer tube connector attached to hose.

(2) Start engine and operate at a speed of 2500 revolutions per minute.

(3) Slowly open manometer tube connector attached to hose while carefully observing liquid level in manometer tube.

**NOTE**

If the crankcase pressure is excessively high, it may exceed the capacity of the manometer. Discontinue the test if the liquid level approaches the limit of the manometer scale by closing the manometer tube connector.

(4) When manometer tube connector has been opened one full turn, measure crankcase pressure indicated on manometer scale.

**NOTE**

Manometer measurements are made by adding together the displacements from zero of the two columns of water. This value is expressed as inches of water.

(6) Increase engine speed to 2800 revolutions per minute.

(7) Measure crankcase pressure indicated on manometer scale.

(8) Measurement made must not exceed 1.0 inch of water.

(9) If requirements are not met, refer to troubleshooting (sec. II, chap. 2).

(10) Disconnect hose from oil gage tube and install oil level gage.

**4-72. Box Pressure Test**

*a. General.* Proper air box pressure is required to maintain sufficient air for fuel combustion and for scavenging of combustion products. Low air box pressure is caused by damaged blower rotors, an air leak from the air box, such as leaking end plate gaskets, or a clogged blower air inlet screen. Lack of power, black or grey exhaust smoke are indications of low air box pressure.

*b. Preparation for Test.*

(1) Prepare a manometer in the same manner as outlined in paragraph 4-71 *b*, using mercury in place of the dye and water.

(2) Remove crankcase ventilation system hose from right air box drain tube and connect hose to air box drain tube. Connect opposite end of hose to one of the manometer tube connector assemblies.

(3) Mount manometer in a vertical position and adjust scale until zero mark is opposite mercury level.

*c. Test Procedure.*

(1) Remove all restrictions to flow of engine exhaust gases so that exhaust back pressure is zero.

(2) Start engine and operate, with no load, at 2500 revolutions per minute.

(3) Measure air box pressure indicated on manometer.

(4) Air box pressure measurement made must not exceed 4.8 inches of mercury.

(5) Install suitable restrictions to flow of exhaust gases from both exhaust manifolds. Provide a suitable means for measuring exhaust back pressure in inches of mercury.

**NOTE**

Measure exhaust back pressure with same manometer prepared for air box pressure test. To connect manometer hose a tap must be provided in the exhaust lines. Plug the tap after test.

(6) Start engine and operate, with no load, at 2500 revolutions per minute.

(7) Adjust exhaust restrictions so that an



exhaust back pressure of 2.7 inches of mercury exists at each exhaust manifold.

(8) Measure air box pressure indicated on manometer.

(9) Air box pressure measurement made must not exceed 8.0 inches of mercury.

(10) If requirements of steps (4) and (9) are not met, refer to troubleshooting (sec. II, chap. 2).

(11) Disconnect hose from air box drain tube and install crankcase ventilation system tube to right air box drain.

#### 4-73. Run-In Procedures

*a. General.* This section describes run-in schedules for overhauled engines prior to being placed in service. Engine run-in is performed after overhaul to assist in breaking in new parts, to detect faulty assembly, to check for leaks, and to determine whether an engine will operate satisfactorily when installed in vehicle.

##### *b. Preparation for Run-In.*

(1) Couple engine to suitable load. The load may be a water brake or electric dynamometer.

(2) Lubricate engine by forcing engine oil under pressure into lubrication system. This will insure adequate lubrication to engine parts until oil is circulated under pressure from engine oil pump. When prelubrication equipment is not available, fill all external lines and oil cooler with proper grade oil. Fill crankcase with proper grade oil to level on liquid level gage rod-cap.

(3) Connect external source of fuel supply to engine. Connect same type air cleaners that are used with engine when installed in vehicle. Air intake should be located so that only cool, fresh air will be inducted in engine. Connect engine cooling system to a suitable heat exchanger or radiator, similar to vehicle type, to properly cool engine. Fill cooling system with coolant. A means must be provided for conducting exhaust gases away from test area. Provide a suitable external source of 24-volt direct current electrical power for starting the engine.

#### 4-74. Run-In

*a. Run-In Schedules.* An overhauled engine should be started and run-in accordance with one of the following schedules.

(1) When any of original bearings, piston rings, or cylinder liners of engine were replaced during overhaul, use long run-in schedule (table 4-12).

(2) When original bearings, piston rings, and cylinder liners were installed during overhaul, use short run-in schedule (table 4-13).

*b. Performance Curve.* Figure 4-61B charts mean performance curve. A variation of plus or minus two percent is acceptable.

Table 4-12. Long Run-In Schedule

| Period | Time (min.) | Engine Speed (rpm.)        | Horsepower |
|--------|-------------|----------------------------|------------|
| 1      | 5           | 600<br>(Start and Warm-Up) |            |
| 2      | 10          | 1800                       | 30         |
| 3      | 30          | 2200                       | 130        |
| 4      | 30          | 2800                       | 171        |
| 5      | 30          | 2800                       | 202        |
| 6      | 5           | 600<br>(Cool Off Period)   | (Minimum)  |

Table 4-13. Short Run-In Schedule

| Period | Time (min.) | Engine Speed (rpm.)        | Horsepower |
|--------|-------------|----------------------------|------------|
| 1      | 5           | 600<br>(Start and Warm-Up) |            |
| 2      | 5           | 1800                       | 30         |
| 3      | 15          | 2200                       | 130        |
| 4      | 15          | 2800                       | 171        |
| 5      | 15          | 2800                       | 202        |
| 6      | 5           | 600<br>(Cool Off Period)   | (Minimum)  |



## CHAPTER 5

## REPAIR OF DRIVE COMPONENTS

## Section I. TRANSMISSION

## 5-1. Transmission

a. *General.* The transmission consists of a single-stage torque converter coupled to a countershaft type transmission having two self-adjusting duplex clutch packs which provide two forward and one reverse ratios of output. The torque converter has an integral lock up clutch which can only be engaged in forward gears and at five wheel. The transmission is operated by a dual purpose shift tower, which selects both forward and reverse, and the low or high range of output. The torque converter lock-up clutch is actuated by a momentary toggle switch on the instrument panel, a microswitch in the shift tower, and a solenoid operated control valve adjacent to the transmission. The transmission oil is cooled by being piped to a cooling core contained in the vehicle radiator. The transmission oil provides all lubrication and positive radial oil flow cooling for the clutch packs.

b. *Removal.* Refer to paragraph 2-7 and remove the transmission assembly.

c. *Disassembly.*

(1) The transmission is composed of several subassemblies; a solenoid control valve, a pump group, a control valve group, a range selector valve assembly, torque converter, forward and reverse clutch groups, output shaft, accessory drive group and the main housing.

(2) Disassembly of the transmission assembly is covered in paragraph 5-2b, which in turn references separate paragraphs for each sub-assembly as they are removed from the main housing assembly.

d. *Cleaning, Inspection and Repair.* Cleaning, inspection and repair of the transmission assembly is covered in each of the following paragraphs as pertains to each respective sub-assembly.

e. *Assembly.* Assemble the transmission assembly in the reverse order of disassembly.

f. *Installation.* Install the transmission in the reverse order of removal (para 2-7).

## 5-2. Main Housing Assembly

a. *General.* The main housing assembly consists of the transmission shell components, adapters and bearing retainers necessary for mating and

alignment of the various subassemblies. The assembly also includes the oil distribution tubes.

b. *Disassembly.*

(1) Remove the 4 screws which attach the solenoid valve to its mounting bracket. Remove the solenoid valve mounting bracket.

(2) Refer to paragraph 5-3, for disassembly of the solenoid valve assembly.

(3) Remove the dipstick from the main housing. Remove drain plugs (21 and 34, fig. 5-1) from adapter housing (12) and main housing (33). Discard preformed packings (22 and 35).

(4) Remove level plug (21) from main housing. Discard preformed packings (22).

(5) Remove six capscrews (3, fig. 5-5). Insert two of the capscrews in threaded holes provided in cover plate (1). Turn the screws sufficiently to lift the pump group from locator pins (15). Remove capscrews (6), that secure tube (7), to pump (10). Refer to paragraph 5-4 for disassembly of the pump group.

(6) Remove capscrew (13, fig. 5-6), three capscrews (16), and washers (12), that secure the control valve group to the transmission. Discard gasket (20). Refer to paragraph 5-5 for disassembly of the control valve group.

(7) Remove two tubes (26, fig. 5-1) and discard preformed packings (25).

(8) Remove six capscrews (5, fig. 5-7) and copper washers (6), that secure the range selector valve group to the collector housing. Discard gaskets (7 and 25). Refer to paragraph 5-6 for disassembly of the range selector valve group.

(9) Remove the capscrews (17 and 20, fig. 5-1), that secure the collector housing (41). Free the gasket face and gently withdraw the collector housing, taking care not to damage the piston rings (23, fig. 5-9 and 5-10). Discard gasket (36, fig. 5-1).

(10) Remove retaining ring (37, fig. 5-1), bearing (38), drive flange (40), and seal (39), from collector housing (41). Discard seal (39).

(11) Remove the six piston (teflon) rings (23, fig. 5-9 and 5-10), with expanders.

(12) Remove two tubes (29, fig. 5-1). Discard the four preformed packings (27).

(13) Remove adapter (1), and tube (44), discarding preformed packing (2 and 27).

(14) Unscrew the flexible drive shaft (8, fig. 5-2). Remove six capscrews (47, fig. 5-1) and connecting plate (46). Discard gasket (45).

(15) Using suitable wood 4 x 4 inch blocks as necessary for support, stand the transmission vertically on the casting flange at the output end of the main housing.

(16) Remove the six capscrews (15, fig. 5-8).

(17) Remove the six nuts (47), washer, "plate" (48), flexible drive plates (31), shims (33), and flywheel pilot (44).

(18) With a suitable hoist and lifting strap, slowly withdraw the converter group from the housing. Refer to paragraph 5-7 for disassembly of the torque converter group.

(19) Remove the twelve capscrews (17, fig. 5-1), and the adapter housing (12). Discard gasket (8). Remove seal (16) and discard.

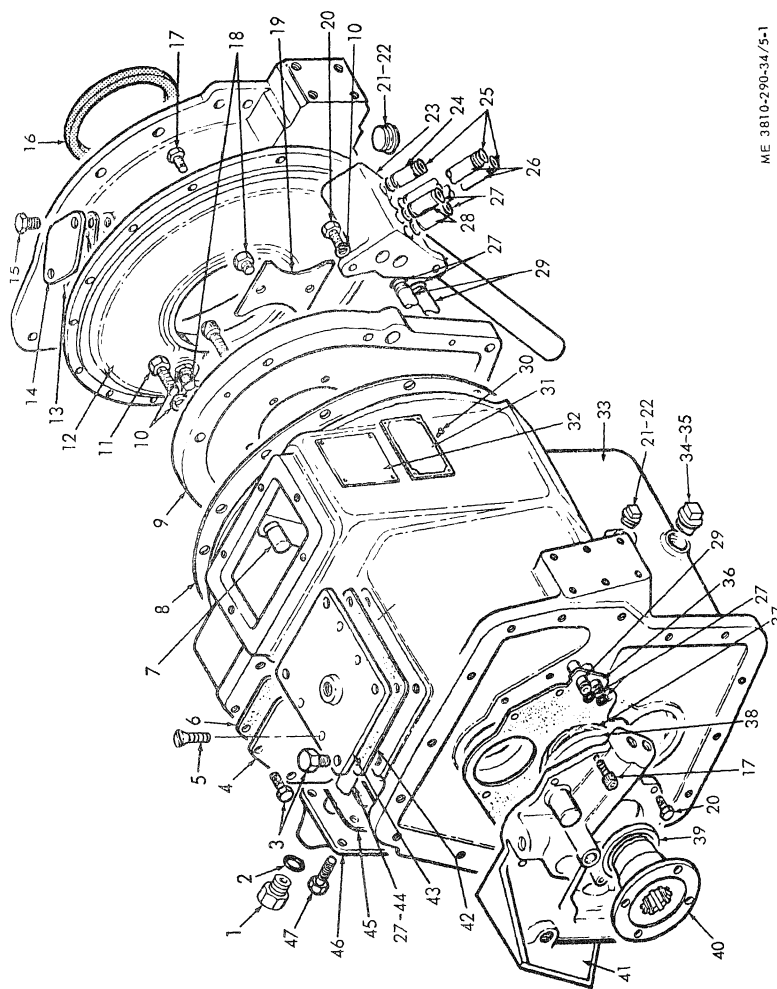
(20) Remove three machine screws (4, fig. 5- ) and tachometer drive assembly (1). Remove four apscrows (9), mounting plate (5), and shim (6). Remove slotted screw (2) and locknut (3). Remove the right angle drive assembly (7) from connector plate (46, fig. 5-1).

#### NOTE

After removing capscrews (9), it may be necessary to swing the support bracket of the converter oil return tube assembly downward to remove mounting plate (5). To turn the oil return tube assembly, loosen the jam nut which secures the tube assembly to the transmission housing. Remove the oil return tube assembly as necessary by unscrewing from transmission housing.

#### KEY to figure 5-1.

1. Adapter
3. Capscrew (8)
4. Cover
5. Screw (4)
6. Gasket
7. Pin (2)
8. Gasket
9. Bearing retainer
10. Washer (19)
11. Capscrew (6)
12. Adapter housing
13. Gasket
14. Cover
15. Capscrew (2)
16. Seal
17. Capscrew (16)
18. Capscrew (3)
19. Retainer
20. Capscrew (6)
21. Plug (2)
22. Preformed packing (2)
23. Connecting block
24. Return tube
25. Preformed packing (6)
26. Converter tube (2)
27. Preformed packing (10)
28. Tube (2)
29. Main tube (2)
30. Drive screw (8)
31. Name plate
32. Instruction plate
33. Main housing
34. Drain plug
35. Preformed packing
36. Gasket
37. Retaining ring
38. Bearing
39. Seal
40. Drive flange
41. Collector housing
42. Gasket
43. Cover
44. Tube
45. Gasket
46. Plate
47. Capscrew (6)



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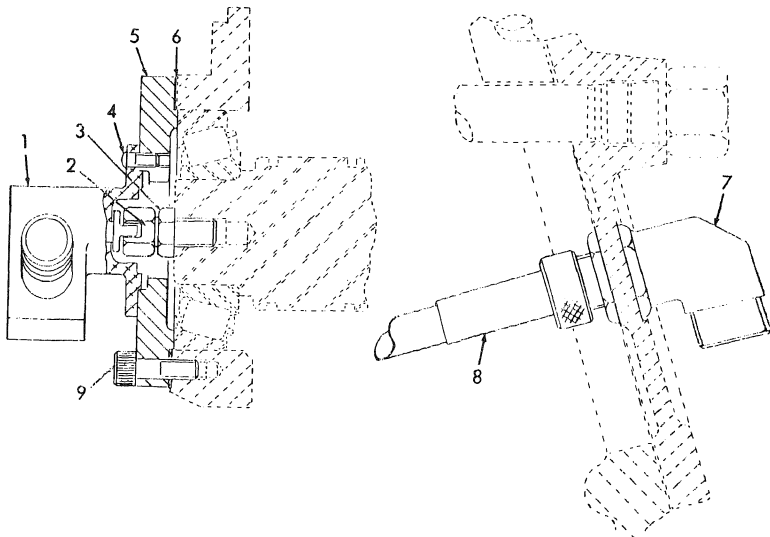
Figure 5-1. Transmission main housing group, exploded view.

(21) Remove two capscrews (20) and washers (10) that secure the connecting block (23). Remove tubes (24 and 28) and discard preformed packings (25 and 27).

(22) Remove the nine capscrews (11 and 18), retainer (19), and bearing retainer (9).

NOTE

Tap the ends of the output shaft and reverse clutch shaft lightly with a soft hammer to free the bearings from the bearing retainer.



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1. Tachometer drive assembly
2. Slotted screw
3. Lock nut
4. Screw (3)
5. Plate
6. Shim set
7. Right angle drive
8. Flexible drive shaft
9. Capscrew (4)

Figure 5-2. Transmission, accessory drive group, cross section view.

(23) Insert two  $\frac{3}{8}$ -UNF eyebolts into the ends of the forward and the reverse clutch shafts. With a suitable hoist lift both clutch groups and the output shaft group about 4 inches. Swing the reverse clutch group and the output shaft back into the bottom of the main housing, and lift the forward clutch group straight out.

(24) Lift out the reverse clutch group and then the output shaft group. Refer to paragraph 5-8 for disassembly of the forward and reverse clutch groups, and paragraph 5-9 for disassembly of the output shaft group.

(25) Remove capscrews (3, fig. 5-1), screws

151, covers (4 and 431, and gaskets (6 and 42) as necessary.

*d. Cleaning, Inspection, and Repair.*

(1) Clean all parts with an approved cleaning solvent and dry thoroughly.

(2) Inspect all tubes for burs, cracks, dents, or other damage. Remove any burs with fine crocus cloth. Replace a tube that is cracked, dented, or badly damaged.

(3) Inspect all castings for scored bores and machined surfaces, cracks, or other signs of damage. Remove minor scoring with fine crocus cloth. Replace a cracked or badly damaged casting.

(4) Inspect all tapped holes for stripped or otherwise damaged threads. Rework threads as necessary.

*e. Assembly.*

(1) Coat all parts with transmission oil, refer to current lubrication order, to facilitate assembly.

(2) Lubricate and install new seals, gaskets, and preformed packings.

(3) Stand the main housing 33, fig. 5-11, on 4 x 4 inch wood blocks in such a manner, which will not obstruct the shaft holes in the output side of the housing.

(4) Place the assembled output shaft group, splined end first, into the bottom of transmission housing. Place the reverse clutch group, by means of a suitable hoist attached to an eyebolt inserted into the tapped end of the shaft.

(5) By the same means lower the forward clutch shaft group into the transmission housing until approximately four inches from the bottom. Raise the reverse clutch group and output shaft group sufficiently to mesh all gears of the three groups. Refer to figure 5-3 for relative positioning of shaft groups.

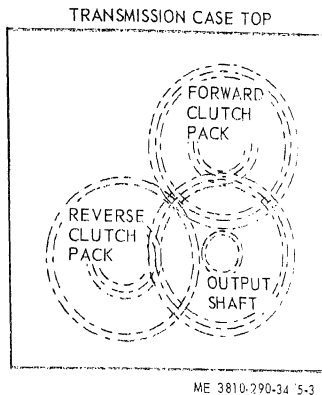


Figure 5-3. Positioning diagram for transmission shafts

(6) With all gears meshed, lower the shaft groups as a unit until the bearings on the bottom of the clutch groups have been seated in their respective bores in the transmission housing.

(7) Position the bearing retainer (9, fig. 5-11, over the reverse clutch shaft bearing, output shaft bearing, and locator pins in transmission housing. Press retainer (9) into place and secure with retainer (19) and capscrews (11 and 18).

(8) Insert tubes (24 and 28), with new preformed packings (25 and 27) into connecting block (23). Position connecting block in transmission housing (33), and secure with two capscrews (20) and washers (10).

(9) Thread locknut (3, fig. 5-2) on slotted

screw (2), and install in end of output shaft. Turn the slotted screw until the top of the head is 0.63 / 0.61 inch from the end of the shaft. Secure the slotted screw in this position by turning locknut (3), against the output shaft.

(10) Attach the tachometer drive assembly (1) to the mounting plate (5) with three machine screws (4). With shims (6), position the assembled tachometer drive assembly and mounting plate over the slotted screw (2), and secure with four capscrews (9).

#### NOTE

One capscrew (9) also secures the oil return tube assembly support bracket.

#### NOTE

Position the tachometer drive assembly, so as to have the tachometer drive output connection pointing directly toward the connector plate (46, fig. 5-1).

(11) Install a new seal (16), in the adapter housing (12). Using a new gasket (8), secure the adapter (12) to the transmission housing (33) with twelve capscrews (17).

(12) With a suitable hoist and lifting strap, slowly lower the converter group into the housing.

#### CAUTION

**When lowering converter into the housing it is important to align the converter carefully with the housing so as not to damage seal (16).**

#### NOTE

It may be necessary to rotate the converter slightly to engage splined end of forward clutch shaft.

(13) Secure the converter group to transmission with six capscrews (15, fig. 5-8). Tighten capscrews to 34—38 pound-feet torque.

(14) Remove lifting strap from converter. Install flywheel pilot (44), shims (33), flexible drive plates (31), and washer, "plate" (48). Secure with six nuts (47). Tighten nuts to 77—85 pound-feet torque.

(15) Mount the right angle drive assembly (7, fig. 5-2) on connector plate (46, fig. 5-1) so as to have the drive output pointing toward the engine. Install the connector plate (46) and gasket (45). Secure with six capscrews (47).

(16) Install flexible drive shaft (8, fig. 5-2). Position new preformed packings (27, fig. 5-1) on tube (44), and install through port in connector plate (46). Install adapter (1) and preformed packing (2).

(17) Position new preformed packings (27) on tubes (29) and insert tubes through the rear of the transmission housing until seated in the connector block (23).

(18) Install six piston (teflon) rings (23, fig. 5-

9 and 5-10), with expanders on the projecting ends of the clutch shaft assemblies.

(19) Install a new seal (39, fig. 5-1) in collector housing (41). Assemble drive flange (40), collector housing (41), bearing (38), and retaining ring (37).

(20) Position the collector housing assembly with gasket (36), over the clutch shafts and splined output shaft. Slide the assembly on as squarely as possible to avoid damage to the piston ring (fig. 5-9 and 5-10). Secure with capscrews (1, and 20, fig. 5-1).

(21) Position the range selector valve group (fig. 5-7), with gaskets (7 and 25), on the collector housing (41, fig. 5-1) and secure with capscrews (5, fig. 5-7) and copper washers (6). Tighten capscrews to 34—38 pound-feet torque.

(22) Position new preformed packings (25, fig. 5-1), on tubes (26) and install through side of transmission housing (33) pushing until seated in carrier guide (14, fig. 5-8).

(23) Position the control valve group (fig. 5-6) with gasket (20) over protruding tubes (24, 26, and 28, fig. 5-1), and secure with capscrews (13, and 16, fig. 5-6) and washers (12). Tighten capscrews to 34—38 pound-feet torque.

(24) Install pump group (fig. 5-5) and align with locator pins (15), in transmission housing. Secure with six capscrews (3). Tighten capscrews to 34—38 pound-feet torque.

(25) Install plugs (21 and 34, fig. 5-1) with preformed packings (22 and 35) respectively. Install dipstick.

(26) Install covers (4 and 43) and gaskets (6 and 42), as necessary, securing with capscrews (3), and screws (5).

(27) Install the solenoid valve mounting bracket on the rear of the transmission housing. Secure the solenoid valve to the bracket with 4 screws.

### 5-3. Solenoid Control Valve Assembly

a. *General.* The solenoid control valve assembly is a solenoid pilot operated three way directional control valve which operates the converter lock-up clutch. The main spool is operated by a pilot pressure of 220 p.s.i., has a spring return mechanism which renders the valve inoperative below a pilot pressure of 180 p.s.i. Oil is ported through the solenoid core at a reduced pressure of 5 to 20 p.s.i. to lubricate the lock-up clutch and to lubricate and cool the exterior of the forward and reverse clutch groups.

#### b. Removal and Disassembly.

(1) Tag and disconnect all hydraulic tubes and hoses, and the electrical lead.



(2) Remove the solenoid control valve assembly, paragraph 5-2.

(3) Remove four-screws that secure solenoid end assembly (1, fig. 5-4), to valve assembly (2).

(4) Separate solenoid end assembly from valve assembly.

(5) Remove four screws that secure end assembly (3), to valve assembly (2).

(6) Separate end assembly and valve assembly.

#### NOTE

Do not attempt further disassembly as the solenoid valve is serviced only by the three subassemblies indicated in figure 5-4.

#### *c. Cleaning, Inspection and Repair.*

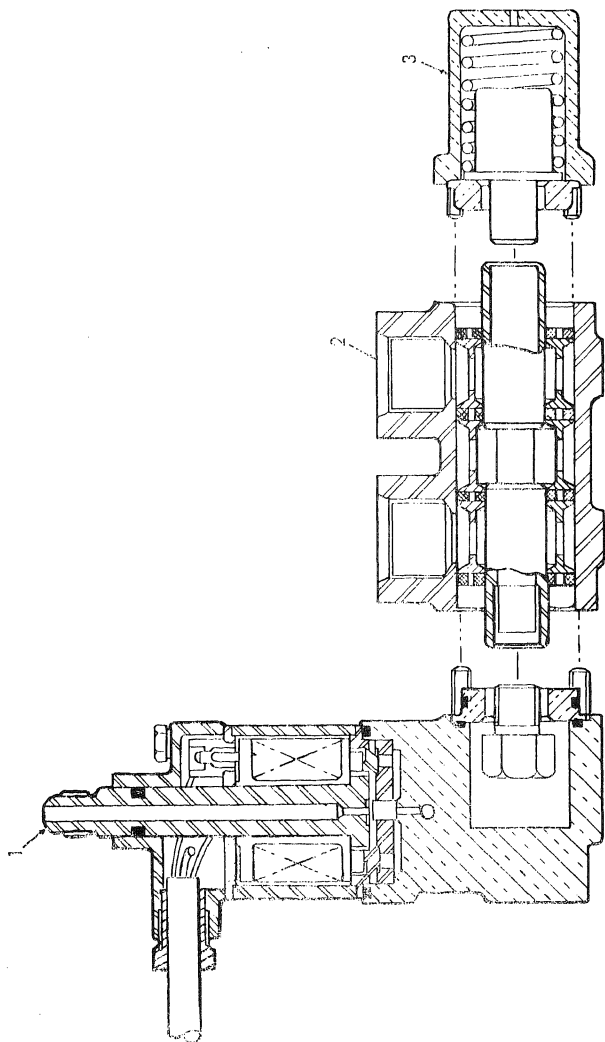
(1) Clean exterior of subassemblies with a damp cloth and dry thoroughly.

(2) Inspect castings for cracks or other damage. Inspect machined mating faces for pitting or scoring. Replace any damaged assembly.

#### *d. Assembly and Installation.*

(1) Assemble the solenoid control valve assembly in reverse of disassembly (para *b*, above).

(2) Install the solenoid control valve assembly (para 5-2).



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Figure 5-4. Transmission solenoid control valve assembly, crosssection view.

**KEY to figure 5-4.**

1. Solenoid end assembly
2. Valve assembly
3. End assembly

**5-4. Oil Pump Group**

*a. General.* The transmission oil pump is gear driven directly from the rotating housing. The pump draws oil from the transmission sump through a screened suction tube, ports the oil directly to the cooling coils in the radiator, and maintains an oil pressure of 220 p.s.i. for proper transmission operation.

*b. Removal and Disassembly.*

- (1) Remove the oil pump group (para 5-2).
- (2) Remove breather (2, fig. 5-5).
- (3) Remove two capscrews (6), suction tube (7), and discard gasket (8).
- (4) Remove retaining ring (5), drive gear (4), and machine key (9).
- (5) Remove four capscrews (11), pump assembly (10), gasket (13), and adapter plate (14). Discard gasket (13).

*c. Cleaning, Inspection and Repair.*

- (1) Clean all parts in an approved cleaning solvent and dry thoroughly with compressed air.
- (2) Inspect the screen of the suction tube for corrosion or other damage that might restrict oil flow.
- (3) Inspect drive gear for signs of excessive wear.

- (4) Replace any part that is damaged or worn.
- d. Assembly and Installation.*

- (1) Assemble the oil pump group in the reverse of disassembly, paragraph *b* above.
- (2) Install new gaskets (8 and 13).
- (3) Tighten capscrews (11) to 34—38 pound-feet torque.
- (4) Install the oil pump group (para 5-2).

**5-5. Control Valve Group**

*a. General.* The transmission control valve group is an externally mounted valve, which distributes the oil from the oil filter to the torque converter and the range selector valve.

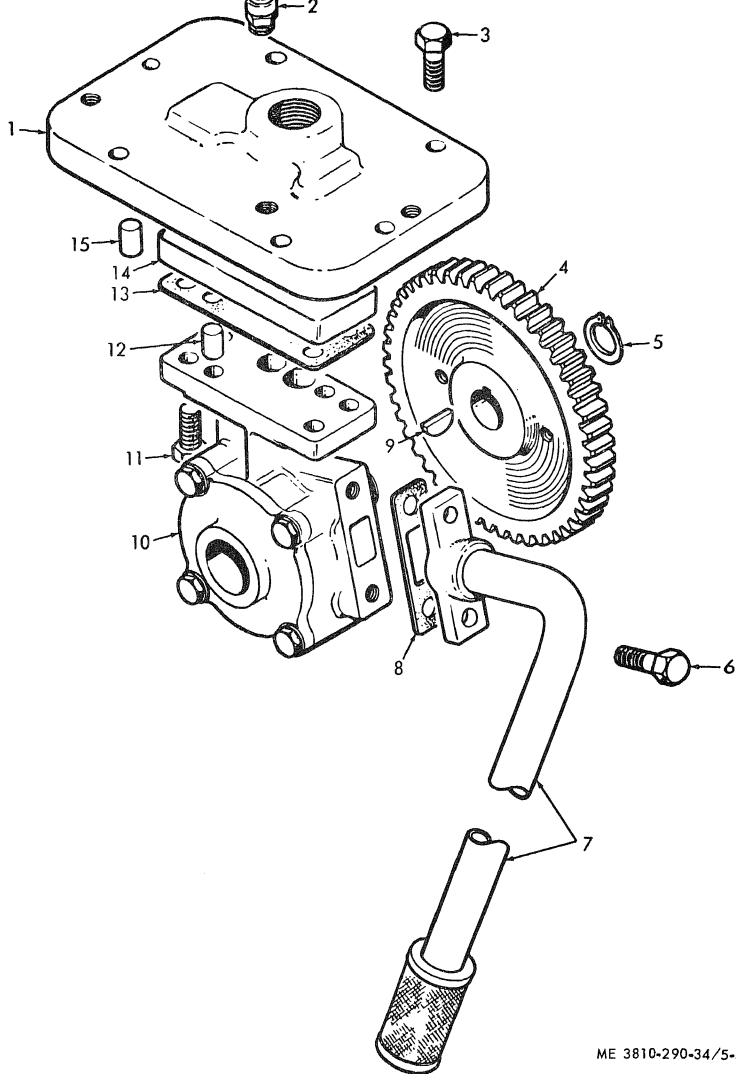
*b. Removal and Disassembly.*

- (1) Remove the control valve group (para 5-2).
- (2) Remove plug (19, fig. 5-6), spring (18), and piston (17).
- (3) Remove capscrews (1), copper washer (12), cover (2), and plate (4). Discard gaskets (3 and 5).

**CAUTION**

Piston (6) is under high spring tension. Use caution when removing cover (2).

- (4) Remove piston (6), springs (7 and 8), and piston (9).
- (5) Remove check ball (10), and spring (11).



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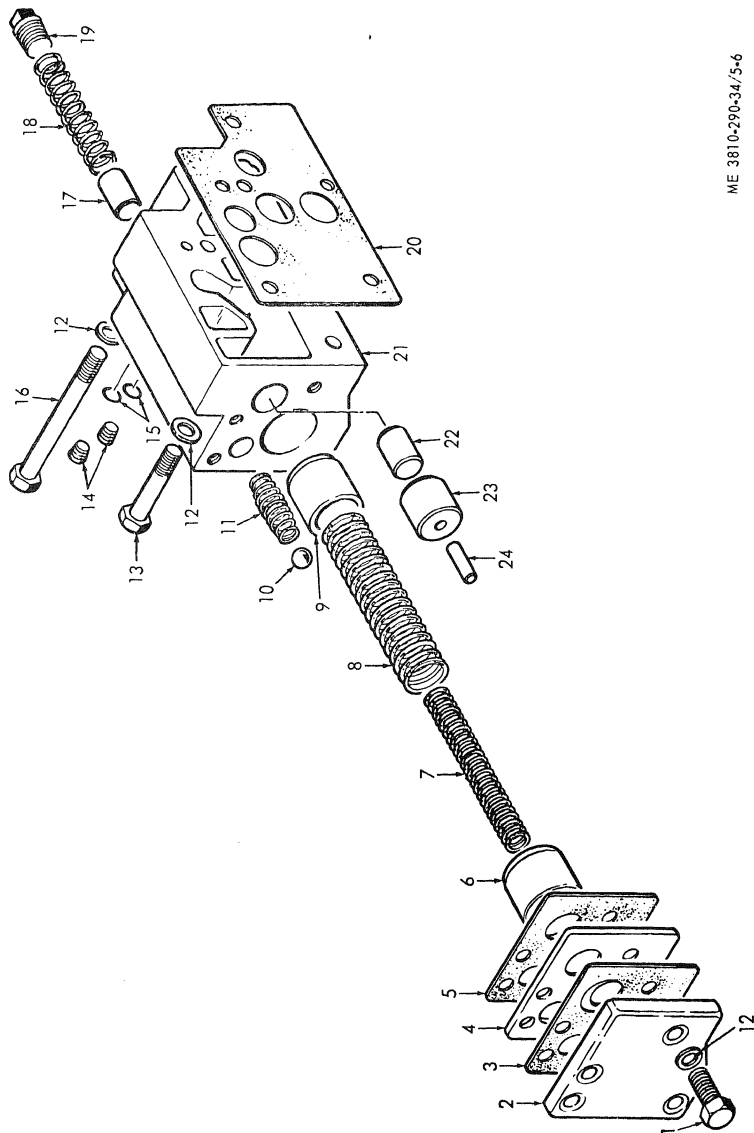
1. Plate
2. Breather
3. Capscrew (6)
4. Gear
5. Retaining ring

6. Capscrew (2)
7. Suction tube w/ strainer
8. Gasket
9. Key
10. Pump

11. Capscrew (4)
12. Pin (2)
13. Gasket (2)
14. Adapter plate
15. Pin (2)

Figure 5-5. Transmission oil pump group, exploded view.





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Figure 5-6. Transmission control group, exploded view.

## KEY to figure 5-6.

1. Capscrew (14)
2. Cover
3. Gasket
4. Plate
5. Gasket
6. Piston
7. Spring
8. Spring
9. Piston
10. Ball
11. Spring
12. Copper washer (8)
13. Capscrew
14. Plug (2)
15. Preformed packing (2)
16. Capscrew (3)
17. Piston
18. Spring
19. Plug
20. Gasket
21. Housing
22. Piston
23. Cylinder
24. Piston

NOTE: Each washer P/N UA1908 and UA1908A not illustrated. For adjustment of control fluid pressure.

(6) Remove piston (24), cylinder (23), and piston (22).

(7) Remove plugs (14) and preformed packings (15), as necessary for cleaning and inspection of the valve housing (21).

#### c. Cleaning, Inspection and Repair.

(1) Clean all parts with an approved cleaning solvent and dry with compressed air.

(2) Inspect the pistons and housing bores for scoring or other damage. Replace a scored or otherwise damaged piston or housing.

(3) Inspect springs for broken, cracked, or deformed condition. Replace any spring which is broken or otherwise damaged.

#### d. Assembly and Installation.

(1) Lubricate all parts with clean transmission oil.

(2) Install new gaskets (3 and 5), and preformed packings (15).

(3) Assemble the transmission control valve group in reverse of disassembly, paragraph *b* above.

(4) Tighten capscrews (1) to 34—38 pound-feet and plug (19) to 35—47 pound-feet torque.

(5) Install the transmission control valve group (para 5-2).

### 5-6. Range Selector Valve Group

*a. General.* The transmission range selector valve is remotely operated by the lever in the shift tower, located in the cab. The valve directs oil flow

to one of the four clutches, providing two speed ranges in both forward and reverse directions.

#### b. Removal and Disassembly.

(1) Remove the range selector valve group (para 5-4).

(2) Remove four capscrews (26, fig. 5-7) and housing (8). Discard gasket (9).

(3) Remove and discard preformed packing (18).

(4) With a suitable puller, remove bearing (10).

(5) Remove four capscrews (15), cover plate (24).

(6) Remove roll pins (14) and plate (22).

(7) Pivot valve (12) until detent plate (17) is free, then slide base plate (16) from shaft (19).

(8) Remove detent ball (13), spring (30) wiper (27), and washers (29), from valve (12). Remove and discard preformed packings (21) and (28).

#### NOTE

Make note of the manner washers (29) are grouped to facilitate assembly in the same manner.

(9) No further disassembly of the valve (12), pin (11), shaft (19), and bearing (20) is practical.

#### c. Cleaning, Inspection, and Repair.

(1) Clean all parts in an approved cleaning solvent and dry with compressed air.

(2) Inspect wiper (27), base plate (16), and detent plate (17), for scoring or signs of wear. Remove minor scoring of wiper and base plate with lapping stone or fine crocus cloth. Replace badly scored or worn parts.

(3) Inspect bearings for rough spots. Rotate bearings by hand to detect roughness. Replace as required.

#### NOTE

Replacement of bearing (20) will necessitate replacement of valve (12), pin (11), and shaft (19) also.

(4) Inspect housing (8), cover (24), and plate (22), for cracks or other damage. Replace parts as required.

#### d. Assembly and Installation.

(1) Lubricate all parts with transmission oil. Install new preformed packings (18, 21, and 28), and gasket (9).

(2) Assemble the range selector valve in reverse of disassembly (para *b*, above). Tighten capscrews (15 and 26) to 34—38 pound-feet torque.

(3) Install the range selector valve group on the transmission (para 5-2).

## 5-7. Torque Converter Group

*a. General.* The torque converter is a single stage unit which incorporates a lock-up clutch for positive mechanical drive. A spur gear is mounted to impeller wheel to provide direct drive to the transmission oil pump.

### *b. Removal and Disassembly.*

(1) Remove the torque converter group (para 5-2).

(2) Remove capscrew (41, fig. 5-8) and clamp plate (40). Discard preformed packing (39).

(3) Remove retaining ring (43), capscrews (7), and washers (6). Lift housing (30), from unit. Remove and discard preformed packing (27).

(4) Remove retaining ring (4) and backing plate (3). Remove clutch plate assembly (51).

(5) Remove four capscrews (35), washers (34), bearing retainer (49), and bearing (45). Discard preformed packing (32).

(6) Remove clutch piston assembly (1) and seal ring (2) from housing (30).

(7) Remove piston ring (46), and lift wheel (29) from shaft (18). Remove retaining ring (36).

(8) Lift guide wheel (26) from unit and remove retaining rings (24), inner race (23), thrust washer (9), freewheel cage (8), rollers (25), and freewheel cam (50). Remove thrust bearing (22).

(9) Remove capscrews (12), plate clamps (10), and impeller wheel (5). Remove and discard preformed packing (11).

(10) Remove pump drive gear (13) and piston ring (20) from carrier guide (14).

(11) Remove carrier guide (14) from shaft (18). Remove the two piston rings (19).

(12) Remove retaining ring (17) and with a suitable puller, remove bearing (16).

### *c. Cleaning, Inspection and Repair.*

(1) Clean all parts except clutch plate assembly (51) in an approved cleaning solvent and dry with compressed air. Clean the clutch plate assembly with a damp cloth and dry thoroughly.

(2) Inspect bearings (16 and 45) for roughness by rotating by hand. Inspect rollers (25), inner race (23) and the freewheel cam (50) for roughness. Replace parts as required.

(3) Inspect impeller (5), wheel guide (26), and wheel (29), for cracks or damaged fins. Replace parts as required.

(4) Inspect the clutch plate assembly (51) for wear. Replace as required.

(5) Inspect faces of clutch piston assembly (1) and backing plate (3), for scoring or other signs of wear. Remove minor scoring with a lapping stone or fine crocus cloth. Replace a badly scored or worn part.

(6) Inspect all other metal parts for cracks, scoring, burs, or other damage. Remove all burs and minor scoring. Replace parts as required.

### *d. Assembly and Installation.*

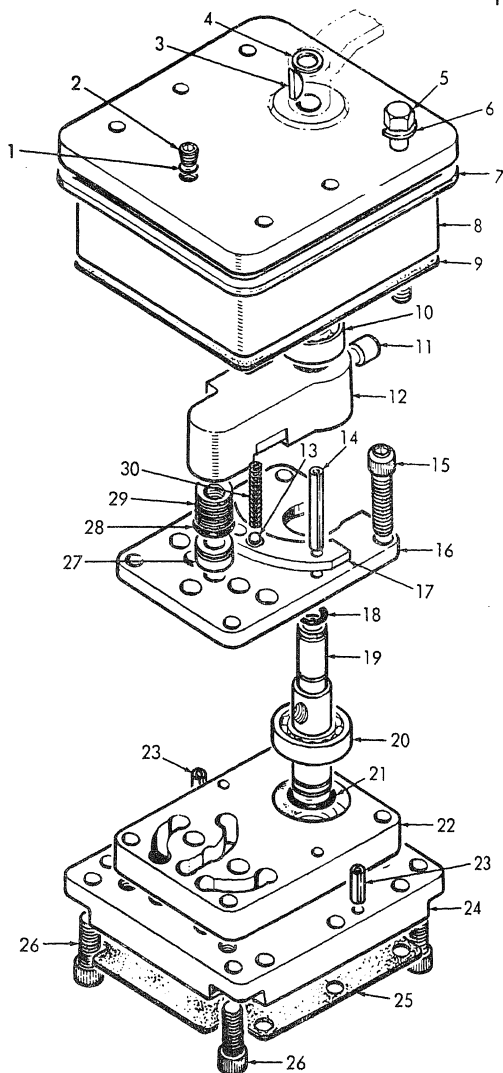
(1) Lubricate all parts with clean transmission oil. Install all new seal rings and preformed packings.

(2) Assemble the torque converter in reverse of instructions in paragraph *b* above.

(3) Tighten capscrews (7 and 41), to 155—170 pound-feet, capscrews (35), to 34—38 pound-feet, and capscrews (12) to 19—21 pound-feet torque.

(4) Install the torque converter (para 5-2).





1. Preformed packing
2. Plug
3. Key
4. Retaining ring
5. Capscrew (6)
6. Copper washer (6)

7. Gasket
8. Housing
9. Gasket
10. Bearing
11. Pin
12. Valve

13. Ball
14. Roll pin (2)
15. Capscrew (4)
16. Base plate
17. Detent plate
18. Preformed packing

19. Shaft
20. Bearing
21. Preformed packing
22. Plate
23. Roll pin (2)
24. Cover

25. Gasket
26. Capscrew (4)
27. Wiper
28. Preformed packing
29. Washer (100)
30. Spring

Figure 5-7. Transmission range selector valve group, exploded view.

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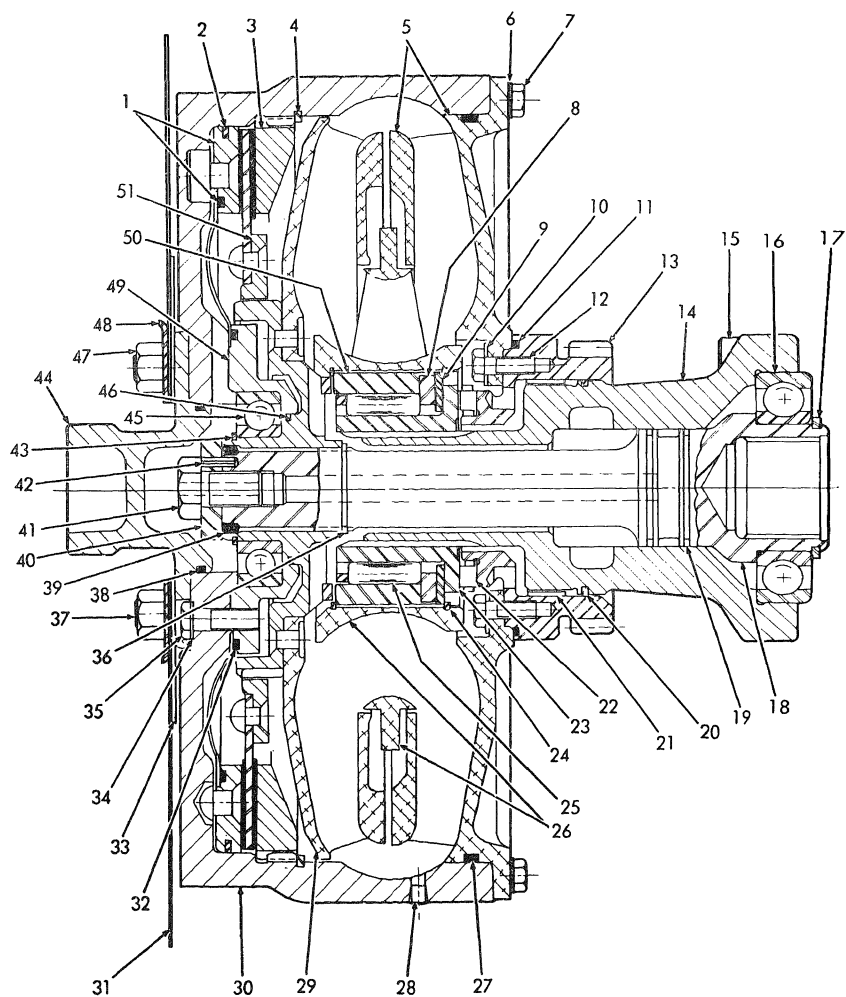


Figure 5-8. Torque converter, cross-section view.

## KEY to figure 5-8.

1. Piston clutch assembly
2. Seal ring
3. Plate, backing
4. Retaining ring
5. Impeller wheel
6. Flat washer (24)
7. Capscrew (24)
8. Freewheel cage
9. Thrust washer
10. Plate clamp (2)
11. Packing, preformed
12. Capscrew (8)
13. Pump drive gear
14. Carrier guide
15. Capscrew (6)
16. Ball bearing
17. Retaining ring
18. Output shaft
19. Piston ring (2)
20. Piston ring
21. Bronze bushing
22. Thrust bearing
23. Inner race
24. Retaining ring (2)
25. Freewheel roller (14)
26. Guide wheel
27. Packing, preformed
28. Pipe plug (2)
29. Wheel
30. Housing
31. Drive plate (3)
32. Packing, preformed
33. Shims
34. Washer (4)
35. Capscrew (4)
36. Retaining ring
37. Stud (6)
38. Packing, preformed
39. Packing, preformed
40. Plate clamp
41. Capscrew
42. Roll pin
43. Retaining ring
44. Pilot flywheel
45. Ball bearing
46. Piston ring
47. Nut (6)
48. Washer
49. Retainer, bearing
50. Freewheel cam
51. Plate clutch assembly

## 5-8. Forward and Reverse Clutch Shaft Groups

*a. General.* The forward and reverse clutch shaft groups are each a dual clutch pack, with one clutch engaging the low speed range gear and the other engaging the high speed range gear. Both clutch shaft groups are identical with interchangeable parts except for the shaft (17, fig. 5-9), and plug (29) of the forward clutch shaft group and the shaft (17, fig. 5-10) and bearing (29) of the

*b. Removal and Disassembly.*

(1) Remove the forward and reverse clutch shaft groups (para 5-2).

## NOTE

The following disassembly is applicable to both the forward (fig. 5-9) and reverse (fig. 5-10) clutch shaft groups.

(2) Remove retaining ring (22), bearing (21), spacer (20), gear (19), two thrust washers (3), and thrust washer (2).

(3) Remove retaining ring (1), bearing (29) (reverse shaft only), thrust washers (2 and 3), and gear (4).

## NOTE

Remove the following from each end of the shaft groups.

(4) Remove retaining ring (5), clutch plate (6), six friction plates (7), and five disc plates (16)

## CAUTION

When handling the friction plates and disc plates, use gloves to prevent corrosion of the plates. Keep plates well coated with transmission oil.

## NOTE

Before further disassembly, measure the distance between the exposed faces of pistons (10). Upon assembly these pistons must be set to this same dimension.

(5) Remove capscrews (8), locknuts (24), pistons (10), springs (11), washers (12), and spacers (27). Remove inner retaining rings (5).

(6) Remove capscrews (15) and locknuts (24). Separate spiders (13 and 25), and gear (28).

(7) Remove retaining ring (26) and plugs (18), from shaft (17). Remove orificed plug (29) (forward shaft only) from shaft.

(8) Remove piston rings (9 and 14) as required.

*c. Cleaning, Inspection and Repair.*

(1) Clean all parts in an approved cleaning solvent and dry with compressed air.

## CAUTION

When handling the friction plates and disc plates, use gloves to prevent corrosion of the plates. Keep plates well coated with transmission oil.

(2) Inspect friction plates (7) for wear or warped condition. New friction plates are grooved approximately 0.010 inch deep on the faces for oil flow. Replace friction plates when groove has disappeared. Coat plates with transmission oil immediately after inspection.

(3) Inspect faces of pistons (10), disc plates (16), and clutch plates (6) for scoring or signs of

stone. Replace a badly scored or worn piston or plates.

**NOTE**

When lapping faces of piston or plates, the face must remain square with their respective bores.

(4) Inspect gears (4, 19, and 28), for broken, cracked, or worn teeth. Replace gears as required.

(5) Inspect spiders for cracks, broken splines, or other damage. Replace as required.

(6) Inspect bearing for roughness by rotating by hand. Replace as required.

**d. Assembly and Installation.**

(1) Lubricate all parts with clean transmission oil.

(2) Assemble the clutch shaft groups in reverse of instructions in paragraph *b* above.

(3) Tighten capscrew (8 and 15) to 34—38 pound-feet and plugs (18) to 7.5—10 pound-feet torque.

**NOTE**

The clutch packs are self-adjusting when assembled, and no further adjustment is necessary.

**5-9. Output Shaft Group**

**a. General.** The output shaft group consists of a low and high speed gear mounted on a straight

splined shaft, which drives the output flange of the transmission.

**b. Removal and Disassembly.**

(1) Remove the output shaft group (para 5-2).

(2) With a suitable puller, remove bearing (1, fig. 5-11).

(3) Remove seal (5) and gear (4). Discard the seal.

(4) Remove retaining rings (6) and gear (2).

**c. Cleaning, Inspection and Repair.**

(1) Clean all parts in an approved cleaning solvent and dry thoroughly.

(2) Inspect gears for broken, cracked, or worn teeth. Replace as required.

(3) Inspect shaft for cracks, burs, or other damage. Remove burs with fine crocus cloth. Replace a cracked or otherwise damaged shaft.

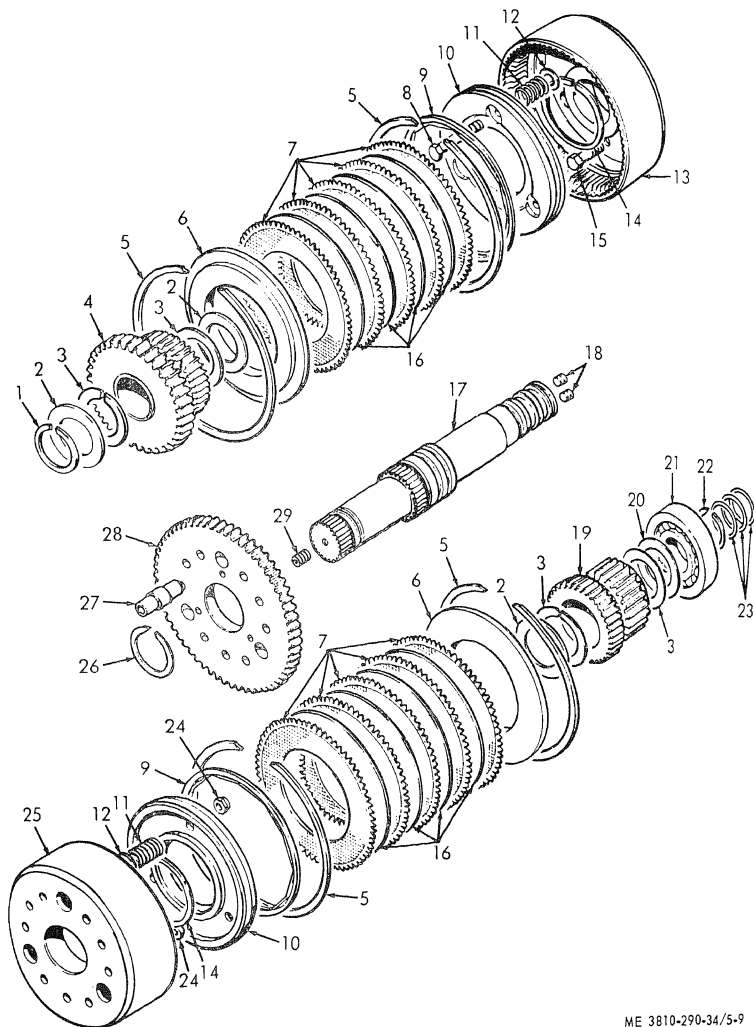
(4) Rotate bearing by hand to detect any roughness in rotation. Replace as required.

**d. Assembly and Installation.**

(1) Lubricate all parts with clean transmission oil. Use a new seal (5).

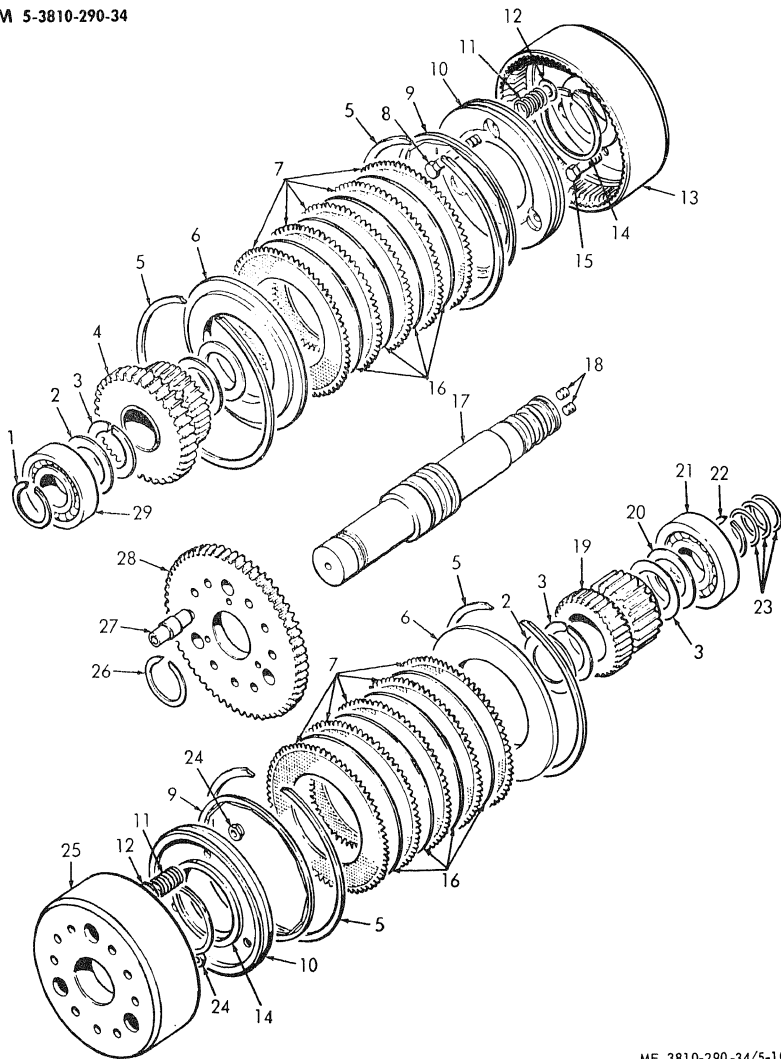
(2) Assemble the output shaft group in reverse of instructions in paragraph *b* above.

(3) Install the output shaft group (para 5-2).



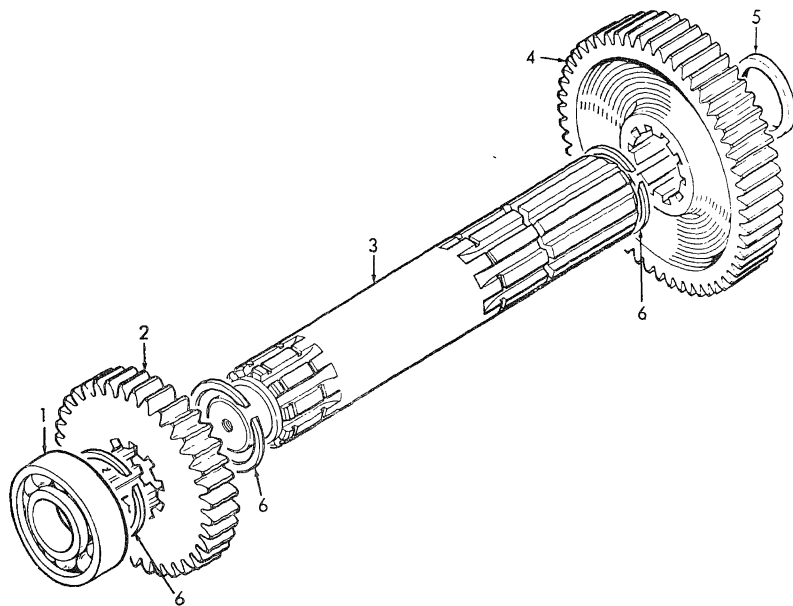
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- |                        |                     |                     |                     |
|------------------------|---------------------|---------------------|---------------------|
| 1. Retaining ring      | 9. Piston ring (2)  | 16. Disc plate (10) | 23. Piston ring (3) |
| 2. Thrust washer (3)   | 10. Piston (2)      | 17. Shaft           | 24. Locknut (12)    |
| 3. Thrust washer (4)   | 11. Spring (6)      | 18. Pipe plug (2)   | 25. Spider          |
| 4. Gear w/ bushing     | 12. Washer (6)      | 19. Gear w/ bushing | 26. Retaining ring  |
| 5. Retaining ring (4)  | 13. Spider          | 20. Spacer          | 27. Spacer (3)      |
| 6. Clutch plate (2)    | 14. Piston ring (2) | 21. Bearing         | 28. Gear            |
| 7. Friction plate (12) | 15. Capscrew (1)    | 22. Retaining ring  | 29. Plug w/ orifice |
| 8. Capscrew (3)        |                     |                     |                     |



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- |                        |                     |                     |                     |
|------------------------|---------------------|---------------------|---------------------|
| 1. Retaining ring      | 9. Piston ring (2)  | 16. Disc plate (10) | 23. Piston ring (3) |
| 2. Thrust washer (3)   | 10. Piston (2)      | 17. Shaft           | 24. Locknut (12)    |
| 3. Thrust washer (4)   | 11. Spring (6)      | 18. Pipe plug (2)   | 25. Spider          |
| 4. Gear w/ bushing     | 12. Washer (6)      | 19. Gear w/ bushing | 26. Retaining ring  |
| 5. Retaining ring (4)  | 13. Spider          | 20. Spacer          | 27. Spacer (3)      |
| 6. Clutch plate (2)    | 14. Piston ring (2) | 21. Bearing         | 28. Gear            |
| 7. Friction plate (12) | 15. Canscrew (01)   | 22. Retaining ring  | 29. Bearing         |



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1. Bearing
2. Gear, high
3. Shaft
4. Gear, low
5. Seal
6. Retaining ring (3)

Figure 5-11. Transmission output shaft group, exploded view.

## Section II. TRANSFER CASE AND TRACTION LOCK SYSTEM

### 5-10. General

The transfer case is mounted behind, and connected to the transmission by a short drive shaft. In turn, the transfer case is connected to the rear and front drive axles by means of shafts equipped with universal joints. A HI-LO speed range (1.415:1 and 2.6:1) to the drive axles is provided by the transfer shift lever located in the crane cab. In addition to the gearing components, a traction lock system is incorporated in the transfer case to overcome loss of traction on either axle. This

feature is controlled by the crane operator by means of a panel control lever.

### 5-11. Transfer Case Assembly

#### a. Removal and Disassembly.

(1) Remove the transfer case in accordance with the instructions given in paragraph 2-5.

(2) Place the transfer case on the work bench or stand for disassembly.

(3) Remove the nuts (27 and 57, fig. 5-12).

washers (26, 56 and 99) and yokes (25, 55 and 98).

(4) Remove governor (48), shaft (47), and sleeve (46).

(5) Remove screws (1) and lockwashers (2) that secure covers (3 and 28), retainer (23), and housing (45). Separate cover, retainer, and housing from transfer case and record amount of shims (4, 5, 29, and 30) removed. Discard gaskets (22 and 44).

(6) Remove and discard seal (24) from retainer (23).

(7) Remove sleeve (51), gear (50), and if required, bushing (49) from housing (45).

(8) Remove screws (96), lockwashers (95), retainer (94), and discard gasket (93). Remove retaining ring (91), bearing (92), and seal (97) from retainer (94) and discard seal.

(9) Remove screws (1) and lockwashers (2) that secure clutch housing (73) and separate assembled clutch housing, differential, and output shafts from transfer case. Discard gasket (74).

(10) Remove bearing (90), retaining ring (89), output gear (88), and key (87) from differential assembly. Remove output shaft (84).

(11) Remove screws (1) and lockwashers (2), and separate cover (58) from clutch housing. Discard gasket (116).

(12) Remove seal (54), retaining ring (53), bearing (52), and clutch bearing (62). Remove and discard preformed packings (59 and 60). Remove pin (61), if replacement is required.

(13) Lift clutch cone (63), output shaft (64), spacers (65), friction disks (66), and opposing disks (67) from clutch disk.

(14) Remove retaining rings (68), clutch disk (69), and pull assembled differential (75 thru 86) from clutch housing (73).

(15) Remove retaining ring (70) and bearing (71) from clutch housing.

(16) Separate front and rear differential cases (77 and 85) by removing four nuts (76) and screws (86). Then separate gears (79), thrust washers (78 and 82), differential pinions (83), and pinion shaft (80). Remove bushings (75) and roll pin (81) only if replacement is required.

(17) Loosen nut (107) and remove rod end (106).

(18) Remove relief fitting (108), screw (109), nut (110), spring (111), and ball (112).

(19) Remove lockwire (6), two screws (7) and end plates (8) from end of input shaft (18).

(20) Remove screws (113), nuts (115), lockwashers (114), and separate cover (100) from transfer case (101).

(21) Lift out the intermediate shaft assembly and disassemble as follows:

(a) Remove lockwires (6), four screws (31), and end plates (32 and 43).

(b) Remove gear (41), key (42), and spacer (40).

(c) Remove bearings (33 and 39), gears (34, 35 and 36), and key (37) from intermediate shaft (38).

(22) Lift input shaft assembly from case and disassemble as follows:

(a) Remove bearing (21), spacer (20), and gear (19) from input shaft.

(b) Remove spacer (10), gear (12), and shift cone (17) from input shaft (18).

(c) Remove bearings (11), spacers (14), and retaining rings (13) from gears (12 and 19).

(23) Remove bearing (9) from transfer case (101).

(24) Lift shifter shaft (105) from case and remove setscrew (16) and shift fork (15).

(25) Press seals (104) from case (101) and cover (100).

#### *b. Cleaning, Inspection, and Repair.*

(1) Clean all parts, including the transfer case, with an approved cleaning solvent. Dry thoroughly with compressed air.

(2) Inspect all gears and shafts for wear and scoring. Remove light scoring with a lapping stone or fine crocus cloth. Replace any shaft or gear with deep scoring or signs of excessive wear.

(3) Rotate all bearings by hand to detect any signs of roughness or damage. Replace as required.

#### **NOTE**

Any bearing with a total radial clearance in excess of 0.0025 inch should be replaced.

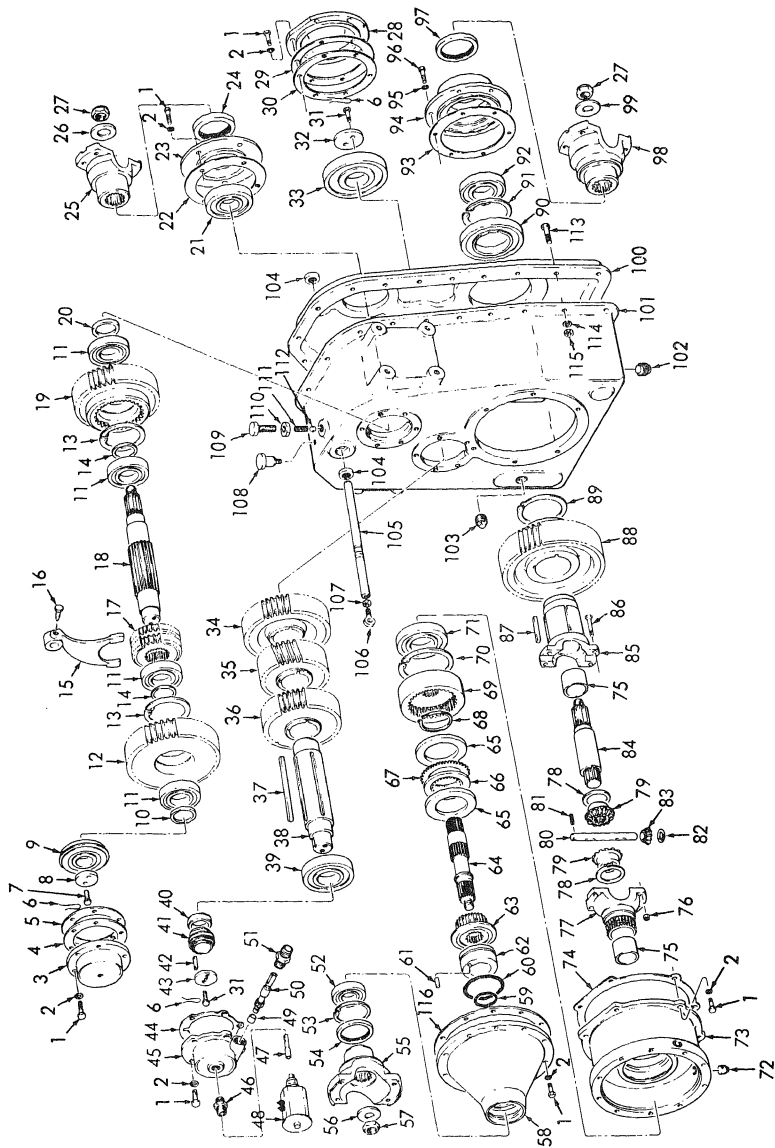
(4) Inspect the discs of the tractionlock (66 and 67) for wear. If wear is noticeable replace the disc assembly.

#### *c. Assembly and Installation.*

(1) Assemble the component parts of the transfer case in the reverse order of disassembly. *Use new gaskets, packing, and seals when assembling.* Tighten all screws to the torque specified (refer to TM 5-3810-290-12), for the respective screw and nut sizes.

(2) Install the transfer case in the carrier (para 2-5).





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Figure 5-12. Transfer case, exploded view.

CFY to figure 5-12.

1. Screw
2. Lockwasher
3. Cover
4. Shim—005
5. Shim—020
6. Wire
7. Screw
8. End plate
9. Bearing
10. Spacer
11. Bearing
12. Gear
13. Retaining ring
14. Spacer
15. Shift fork
16. Setscrew
17. Shift cone
18. Input shaft
19. Gear
20. Spacer
21. Bearing
22. Gasket
23. Retainer
24. Seal
25. Yoke
26. Washer
27. Nut
28. Cover
29. Shim—020
30. Shim—005
31. Screw
32. End plate
33. Bearing
34. Spur gear
35. Drive gear
36. Spur gear
37. Key
38. Countershaft
39. Bearing
40. Spacer
41. Gear
42. Key
43. End plate
44. Gasket
45. Housing
46. Sleeve
47. Shaft
48. Governor
49. Bushing
50. Gear
51. Sleeve
52. Bearing
53. Retaining ring
54. Seal
55. Yoke
56. Washer
57. Nut
58. Cover
59. Packing
60. Packing
61. Pin
62. Bearing
63. Clutch cone
64. Shaft
65. Spacer

66. Friction Disk
67. Opposing Disk
68. Retaining ring
69. Clutch disk
70. Retaining ring
71. Bearing
72. Pipe plug
73. Clutch housing
74. Gasket
75. Bushing
76. Nut
77. Front diff. case
78. Thrust washer
79. Gear
80. Pinion shaft
81. Roll pin
82. Thrust washer
83. Diff. pinion
84. Shaft
85. Rear diff. case
86. Screw
87. Key
88. Gear
89. Retaining ring
90. Bearing
91. Retaining ring
92. Bearing
93. Gasket
94. Retainer
95. Lockwasher
96. Screw
97. Seal
98. Yoke
99. Washer
100. Cover
101. Transfer case
102. Pipe plug
103. Pipe plug
104. Seal
105. Shaft
106. Rod end
107. Nut
108. Relief fitting
109. Screw
110. Nut
111. Spring
112. Ball
113. Screw
114. Lockwasher
115. Nut
116. Gasket

## 5-12. Tractionlock System

*a. General.* The tractionlock system incorporated in the carrier drive system to compensate for loss of traction on any wheel or either axle is an air controlled-hydraulic system. The system is engaged or disengaged by means of a toggle type air valve located on the instrument panel. The power cluster is essentially an air chamber coupled directly to a brake master cylinder for approximately a 1:8 ratio step up from the air pressure input to the hydraulic

output. The pressurized hydraulic fluid then engages the clutches in the axles and transfer case for complete, positive traction.

*b. Removal and Disassembly.*

- (1) Remove the power cluster (para 2-6).
- (2) Remove three capscrews (28, fig. 5-13), lockwashers (27) and spacer (26).
- (3) Remove two capscrews (13) and lockwashers (14) and separate air chamber from master cylinder, removing the seal (12).
- (4) Remove stroke indicator assembly (21) and lockwasher (15).
- (5) Remove three capscrews (16), lockwashers (15), and bracket (17) from the air chamber.
- (6) Remove eight capscrews with lockwashers (12) that secure shell (1) to the head (8).
- (7) Lift out piston and rod assembly (5) and remove and discard piston cup (3) and wiper (4).
- (8) Lift off spring (6) and remove boot (7) from head assembly (8).
- (9) If necessary for replacement, retainer (9), filter (10), and filter screen (11) can be removed.
- (10) Remove plug (22) and discard gasket (23).
- (11) Remove plug (41) and washer (42).
- (12) Remove retainer ring (18) and lift out plate (19), piston (20), cups (35 and 34) and spring assembly (33) from master cylinder body (24).
- (13) Remove bolt (40), washer (39), tee fitting (38), washer (36), and tube fitting plug (37).

*c. Cleaning, Inspection, and Repair.*

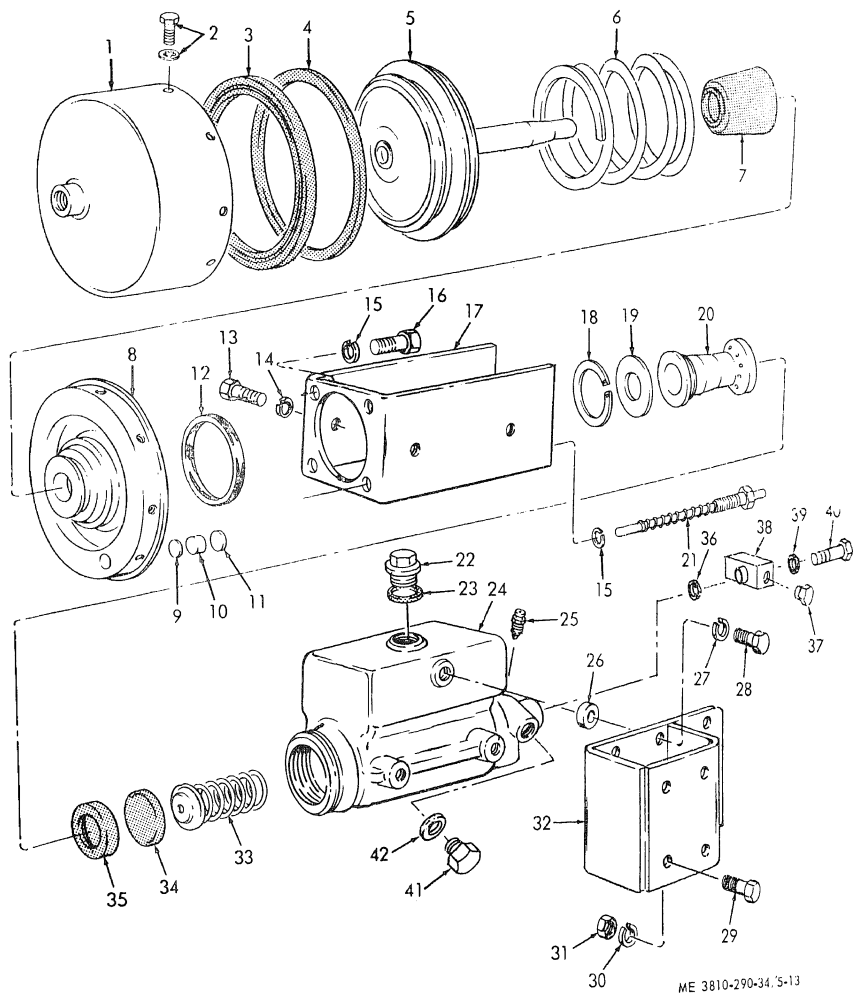
- (1) Clean all metal parts with an approved cleaning solvent and dry with compressed air.
- (2) Inspect all parts for cracks, scratches, burrs, sharp edges or other damage.
- (3) Remove any burrs and break sharp edges found. Replace any part that is cracked, deeply scratched or otherwise badly damaged.

*d. Assembly and Installation.*

- (1) Replace all rubber cups, wipers, and the boot with new parts.
- (2) Inspect all parts for cracks, scratches, burrs, sharp edges or other damage.
- (3) Remove any burrs and break sharp edges.
- (4) Install the power cluster (para 2-6).

Key to figure 5-13.

1. Shell
2. Screw, assembled washer
3. Piston cup & spring assembly
4. Piston wiper
5. Rod & piston assembly
6. Spring
7. Boot
8. Cylinder head assembly
9. Retainer
10. Filter
11. Filter screen
12. Seal ring
13. Capscrew
14. Lockwasher
15. Lockwasher
16. Capscrew
17. Bracket
18. Retaining ring
19. Plate
20. Piston assembly
21. Stroke indicator assembly
22. Pipe plug
23. Gasket
24. Air cylinder assembly
25. Bleeder screw
26. Spacer
27. Lockwasher
28. Capscrew
29. Capscrew
30. Lockwasher
31. Nut
32. Bracket
33. Spring & retainer assembly
34. Cup
35. Cup
36. Washer
37. Plug, tube fitting
38. Fitting, tee
39. Washer
40. Bolt, fluid passage
41. Plug, machine
42. Washer



ME 3810-290-34, 5-13

Figure 5-13. Power cluster assembly, exploded view.

### Section III. WHEEL HUB, PLANETARY DRIVE, AND BRAKE ASSEMBLIES

#### 5-13. General

Each axle mounts two planetary, wheel hub, and brake assemblies. The front and rear assemblies are identical with the exception of the brake chambers. The braking chambers differ in that the rear braking system uses a heavy duty dual-diaphragm chamber, whereas the front chamber, also a dual-diaphragm unit, is of lighter construction. The brake assembly components are identical, and the disassembly, repair, and installation details are the same. Disassembly does not require removal of the axle.

#### 5-14. Wheel Hub and Planetary Drive

##### a. Removal.

(1) Remove the wheel assembly (refer to TM 5-3810-290-12).

(2) Remove the plug (34, fig. 5-14) from hub (32) and drain the lubricant.

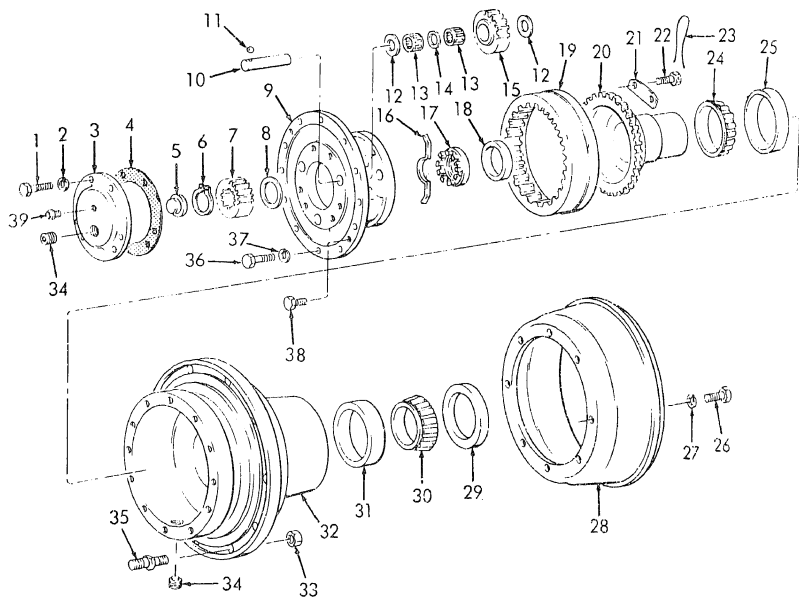
(3) Remove the capscrews (1), lockwashers (2), cover (3), and gasket (4). *Discard the gasket.*

(4) Remove the capscrews (36), lockwashers (37), and capscrews (38).

(5) Remove thrust button (5), retaining ring (6), spur gear (7), and thrust washer (8).

(6) Insert two bolts in the threaded holes in the spider (9) and with suitable puller, remove the spider assembly.

(7) Remove the skein locknut key (16) and using the skein locknut wrench, remove the skein locknut (17).



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Key to figure 5-14.

- |                       |                             |
|-----------------------|-----------------------------|
| 1. Capscrew (6)       | 21. Retainer (4)            |
| 2. Lockwasher (6)     | 22. Capscrew (8)            |
| 3. Cover              | 23. Lockwire (8)            |
| 4. Gasket             | 24. Brg. cone               |
| 5. Thrust button      | 25. Brg. cup                |
| 6. Retaining ring     | 26. Capscrew (8)            |
| 7. Gear, spur         | 27. Lockwasher (8)          |
| 8. Thrust washer      | 28. Brake drum              |
| 9. Spider             | 29. Seal                    |
| 10. Pin (3)           | 30. Brg. Cone               |
| 11. Ball (3)          | 31. Brg. cup                |
| 12. Thrust washer (6) | 32. Hub                     |
| 13. Needle brg. (16)  | 33. Nut (10)                |
| 14. Spacer (3)        | 34. Magnetic plug (2)       |
| 15. Planet gear (3)   | 35. Wheel stud (10)         |
| 16. Key               | 36. Capscrew (12)           |
| 17. Lock nut          | 37. Lockwasher (12)         |
| 18. Bushing           | 38. Capscrew (2)            |
| 19. Ring gear         | 39. Pressure relief fitting |
| 20. Ring gear hub     |                             |

Figure 5-14. Planetary outer end, wheel hub and brake drum assemblies, exploded view.

NOTE

Quantities given in legend are for one wheel assembly.

(8) Remove the assembled ring gear (19) and

hub (20). The bearing cone (24) will remain attached to the ring gear hub.

(1) Remove cap screws (26), fig. 5-14, and lockwashers (27). Remove brake drum (28) from hub (32).

(2) Remove seal (29), bearing cone (30), and bearing cups (25 and 31) from the hub (32).

(3) With suitable puller remove bearing cone (24) from hub (20).

(4) Remove lockwire (23), cap screws (22), retainers (21) and separate ring gear (19) from hub (20).

(5) Bushing (18) should only be removed if inspection indicates replacement is necessary.

(6) Press out pins (10) and ball (11) from spider (9) and remove planetary gears (15).

(7) Remove thrust washers (12), needle bearings (13), and spacers (14), from planetary gears.

#### *c. Cleaning, Inspection, and Repair.*

(1) Clean all parts with an approved cleaning solvent and dry thoroughly with compressed air.

(2) Inspect the brake drum for scoring. Remove scoring by turning on a lathe but do not turn in excess of 17.325 to 17.335 inches inside diameter. This will allow 0.040 inch wear after reborring. If these dimensions are exceeded, replace the brake drum.

(3) Inspect bearings, needle and roller, for rough spots. Rotate by hand to detect roughness. Inspect bearing cups for surface smoothness. Replace thrust washers if scored. Replace parts as required.

(4) Inspect the spur gear (7), planetary gears (15), and ring gear (19) for wear on teeth. The normal backlash is 0.007 to 0.011 inch. If the backlash exceeds 0.018 inch, replace the gears.

#### **NOTE**

Irregular wear on gear teeth may be caused by worn bearings (13), worn pins (10), or worn bushing (18). Replace as required.

(5) Inspect wheel studs (35) for stripped threads or other damage. Replace as necessary.

#### *d. Assembly.*

(1) Position hub (20) on ring gear (19) and secure with retainers (21), cap screws (22) and lockwire (23).

(2) Install bearing cone (24) on hub (20).

(3) Install bearing cups (25 and 31), bearing cone (30), and a new seal (29) in hub (32). Lubricate seal with G090.

(4) Install brake drum (28) on hub (32) and secure with cap screws (26) and lockwashers (27). Torque to 160—180 pound-feet.

(5) Assemble planetary gears (15), needle

#### *e. Installation.*

(1) Install the assembled hub (32) and brake drum (28).

(2) Install the assembled ring gear (19) and hub (20).

(3) Install locknut (17) and tighten to obtain a breakaway force of 15-20 lbs. at the 15.12 inch diameter of hub (32). Secure locknut in position by inserting keys (16).

(4) Install the spider assembly (9) and secure with cap screws (36) and lockwashers (37). Torque cap screws to 100—110 pound-feet. Replace the two cap screws (38).

(5) Install the thrust washer (8) and spur gear (7) securing with retainer ring (6).

(6) Install thrust button (5) in cover (3).

(7) Place a new gasket (4) on cover (3) and position on spider (9) with arrow pointing opposite the drain hole in the hub (32). Secure with six cap screws (1) and lockwashers (2). Torque cap screws to 50—58 pound-feet.

(8) Install drain plug (34) in hub (32), service planetary housing in accordance with current lubrication order, and install fill plug (34).

(9) Install the wheel assembly (refer to TM 5-3810-290-12).

### **5-15. Brake Assemblies**

#### *a. Removal and Disassembly.*

(1) Remove the wheel hub and planetary drive (para 5-14).

(2) Disconnect the brake chamber clevis from the slack adjuster arm.

(3) Remove the springs (2 and 4, fig. 5-15), rollers (3), retaining rings (10), brake shoes (1), and anchor pin (20).

(4) Remove the retainer ring (13), slack adjuster (14), spacer (15), actuating shaft (5), washer (6), and seals (7). Discard the seals (7).

(5) Remove the nuts (12), lockwashers (11), spider (9), and dust shields (16).

#### *b. Cleaning, Inspection, and Repair.*

(1) Clean all parts with an approved cleaning solvent and dry thoroughly with compressed air.

#### **NOTE**

Do not immerse the brake linings in solvent. Wipe clean with a moistened cloth. Remove glazed spots with fine abrasive cloth.

(2) Measure the brake lining thickness. Replace brake linings when worn to 0.250 inch thickness. New molded brake linings are 0.750 inch thick. Secure new brake linings (18, fig. 5-15) with flat head screws (17) and nuts (19), making

sure screw heads are seated properly, and provide 0.500 inch or more brake lining material above the screw heads.

(3) Inspect nylon bushings (8) in spider (9) and socket (35, fig. 5-16). A new bushing measures 1.50 inches inside diameter. Replace a badly worn or scored bushing.

(4) Inspect roller (3, fig. 5-15), actuating shaft (5), washer (6), and spacer (15) for excessive wear, scoring, or burred edges. Remove scoring and burrs with fine crocus cloth. The minimum diameter of the rollers (3) is 0.125 inches and the minimum measurement (center to extreme lobe edge) on the actuating (cam) shaft is 1.875 inches. Replace a badly worn or scored part.

(5) Inspect brake retainer and tension springs (2) and (4) for cracks or other signs of damage. Replace as required.

(6) Inspect slack adjuster for defects. Replace as required.

*c. Reassembly and Installation.*

(1) Position dust shield (16, fig. 5-15) and

spider (9) on studs of axle skein and secure with lockwashers (11) and nuts (12).

(2) Install new seals (7) in spider (9) and socket (24, fig. 5-16).

(3) Position washer (6, fig. 5-15) on actuating shaft (5) and install shaft in spider and socket. Install spacer (15).

(4) Install rollers (3) and springs (2) on brake shoes (1).

(5) Position brake shoes with spider and install anchor pin (20) and retainer rings (10). Install tension spring (4).

(6) Install slack adjuster (14) on actuating shaft (5) and secure with retaining ring (13).

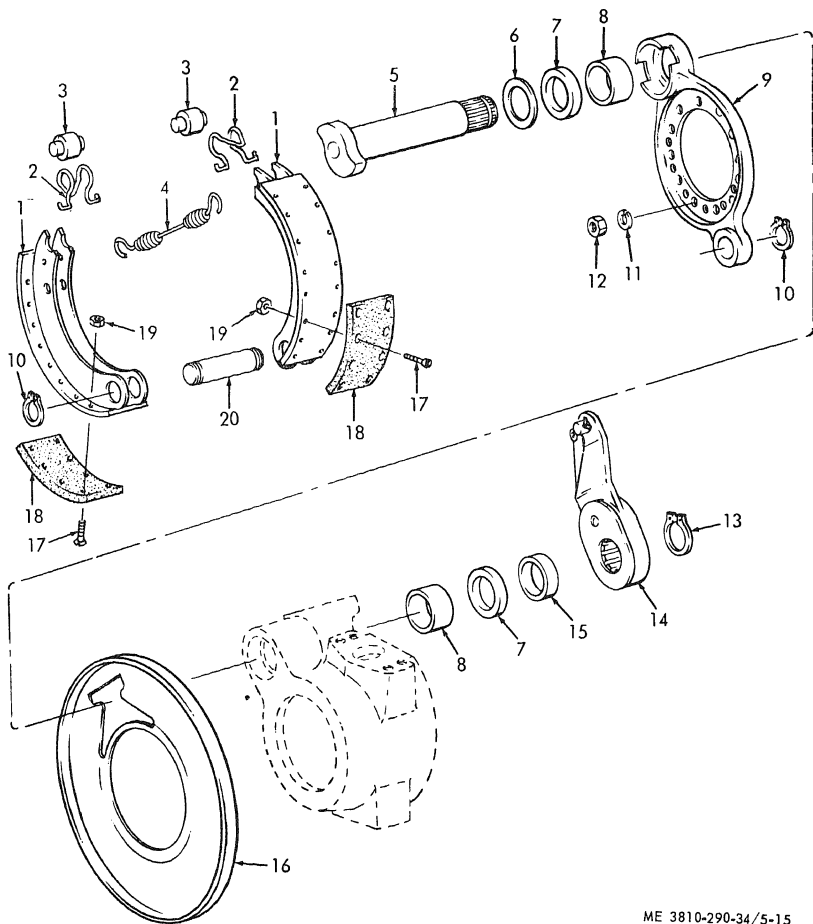
**NOTE**

Slack adjuster must be installed with the ratchet assembly facing away from the air chambers.

(7) Install wheel hub and planetary drive (para 5-14).

(8) Adjust slack adjusters (refer to TM 5-3810-290-12).





ME 3810-290-34/5-15

1. Brake shoe (2)

2. Spring (2)

3. Roller (2)

4. Spring

5. Actuating shaft

6. Thrust washer

7. Seal (2)

8. Bushing, NM (2)

9. Spider

10. Retaining ring (2)

11. Lockwasher (12)

12. Nut (12)

13. Retaining ring

14. Slack adjuster

15. Spacer

16. Dust shield

17. Screw (32)

18. Lining (4)

19. Nut (32)

20. Anchor pin

Figure 5-15. Brake assembly, exploded view.

## 5-16. General

The front and rear axle assemblies are very similar units, consisting of the main axle housing, inner and outer axle shafts, ball journals, and sockets, and axle skein. The axle housings and steering arms are different from front to rear, however, most parts are interchangeable. The following paragraph on axle assembly repair is applicable to both front and rear axle assemblies.

## 5-17. Axle Assembly

*a. Removal.*

(1) Install blocking to support the undercarriage protection plate.

**WARNING**

Do not remove capscrews from front of arms without supporting the undercarriage protection plate.

(a) Remove four capscrews, lockwashers, and flatwashers that secure front of outrigger arms to outrigger box.

(b) Remove pivot pins from rear box.

(c) Remove pivot pins from rear of arms, and remove protection plate.

(2) Jack up the carrier frame sufficiently to provide clearance for removal of the wheels.

**CAUTION**

Install adequate blocking to support the carrier.

(3) Disconnect the propeller shaft at the universal joint at each axle. Disconnect the hydraulic lines connected to each axle, and hydraulic lines connected to each steering cylinder.

(4) Remove the wheels (refer to TM 5-3810-290-12).

(5) Remove the front axle by:

(a) Disconnecting the power steer control arm at the drag link end, and the air lines at the brake chambers. Remove one brake chamber (refer to TM 5-3810-290-12).

(b) Placing a dolly under the axle and install sufficient blocking to support the axle.

(c) Remove the nuts (34, fig. 2-4), lockwashers (33), and capscrews (29).

(d) Remove the axle by pulling out the dolly from the side of the crane. Place the axle on a suitable work stand or supports.

(6) Remove the rear axle by:

(a) Disconnecting the air lines to the brake chambers and lock chamber. Remove one brake chamber. Place a dolly under the axle and install sufficient blocking to support the axle.

(b) Remove the nuts (37, fig. 2-4), lock-

washers (36), and caps (35). Remove sufficient blocking in order that the pivot frame (32) will clear the carrier frame.

(c) Remove axle by pulling out the dolly from the side of the crane.

(d) Remove the nuts (34), lockwashers (33), capscrews (29), and the pivot frame (32) from the axle. Place the axle on a suitable work stand or supports.

(e) Inspect and replace any damaged or excessively worn parts on the pivot frame before replacing on the axle.

(7) Remove the wheel hub and planetary drive (para 5-14).

(8) Remove the brake assemblies (para 5-15).

(9) Remove plug (16), fig. 5-16) and drain lubricant from the axle housing (15).

*b. Disassembly.*

(1) Tap skein (1) with soft hammer and remove.

(2) Remove outer and inner axle assembly (2, 3, 7, 8 and 9) seal (4), retaining ring (5), and ball bearing (6) from axle housing (15).

(3) Remove cotter pins (25), nuts (26) and tie rod assembly.

**NOTE**

Disassembly is identical for each end except that steering arm (39) is replaced by a cover on opposite end.

(4) Remove eight nuts (37), steering arm (39), tie rod arm (30), shims (31), and top caps (36).

(5) Remove capscrews (10), lockwashers (11), retainer connectors (12), seal retainer (13), and packing (50) from rear of socket (35).

(6) Remove the shouldered shafts (32) from the top and bottom of the socket (35) with suitable tool.

(7) Remove the socket from the ball (44). Remove the bearing cones (42).

(8) Remove nuts (45), capscrow (40), and lockwashers (41) and (46). Remove the ball (44) from the axle housing (15).

(9) Remove the seals (49) and 48) from the rear of the ball. Discard seals and packing (50).

*c. Cleaning, Inspection, and Repair.*

(1) Clean all parts with an approved cleaning solvent and dry with compressed air.

(2) Inspect the bearing cones (42) for worn or damaged rollers. Inspect bearing cups (43) for wear or rough spots. Replace as required.

(3) Inspect shafts (32) for wear or scored areas. Replace as required.

(4) Inspect all studs and capscrews for worn or damaged threads. Replace as required.

(5) Inspect axle shaft assembly for play in cage (3 and 9). Torque cage screws (2) to 85-95 pound-feet. End play between inner (8) and outer (7) axle should not exceed 0.006—0.008 inch. Radial (angular) play between axles should not exceed two degrees. Inspect splined ends of shafts for signs of wear or damaged teeth. Replace shafts and cages as required.

(6) Inspect interior of socket (35) for wear or signs of scoring, cracks, or damage. Replace as required.

(7) Inspect surface of ball (44) for scoring or rough spots. Replace ball as required.

(8) Inspect tie rod socket assemblies (27) and shims (30) for wear. Replace as required.

(9) Inspect steering arm (39), (rear steer lock plate on rear axle) for wear or damage. Replace as required.

(10) Inspect axle housing (15) for wear, cracks, or damage. Replace as required.

#### d. Assembly.

(1) Install new seal (48) in ball (44). Place new seal (49) over rear of ball.

(2) Install ball on axle housing (15) and attach with lockwashers (41) and (46), nuts (45), and capscrews (40). Torque nuts and capscrews to 370—390 pound-feet.

(3) Lubricate bearing cones (42), cups (43), and install in balls (44).

(4) Position socket (35) on ball. Secure in plate by pressing shouldered shafts (32) into the bearing cones (42).

(5) Position the seal (49) in the rear of the socket, install packing (50) and secure with the seal retainers, (13), retainer connections (13), capscrews (10), and lockwashers (11). Torque capscrews to 15—20 pound-feet.

(6) Install top cap (36), shims (31), steering arm (39), and tie rod arm (30). Secure with nuts (37). Torque nuts to 290—300 pound-feet.

#### NOTE

After assembly and torquing nuts, the socket (35) should move freely on the ball (44) without binding or excessive play. The shims (31) are supplied in three thicknesses: 0.005, 0.010, and 0.015 inches. Add or remove shims as required to provide 20-25 pound-foot torque on the bearings (42).

(7) Install the tie rod assembly and secure with nuts (26) and cotter pins (25).

(8) Install seal, retaining ring, ball bearing, and inner and outer axle assembly in the axle housing (15).

(9) Install the axle skein (1).

#### e. Installation.

(1) Install the front and rear axles by reversing the order of removal.

(2) Service in accordance with current lubrication order.

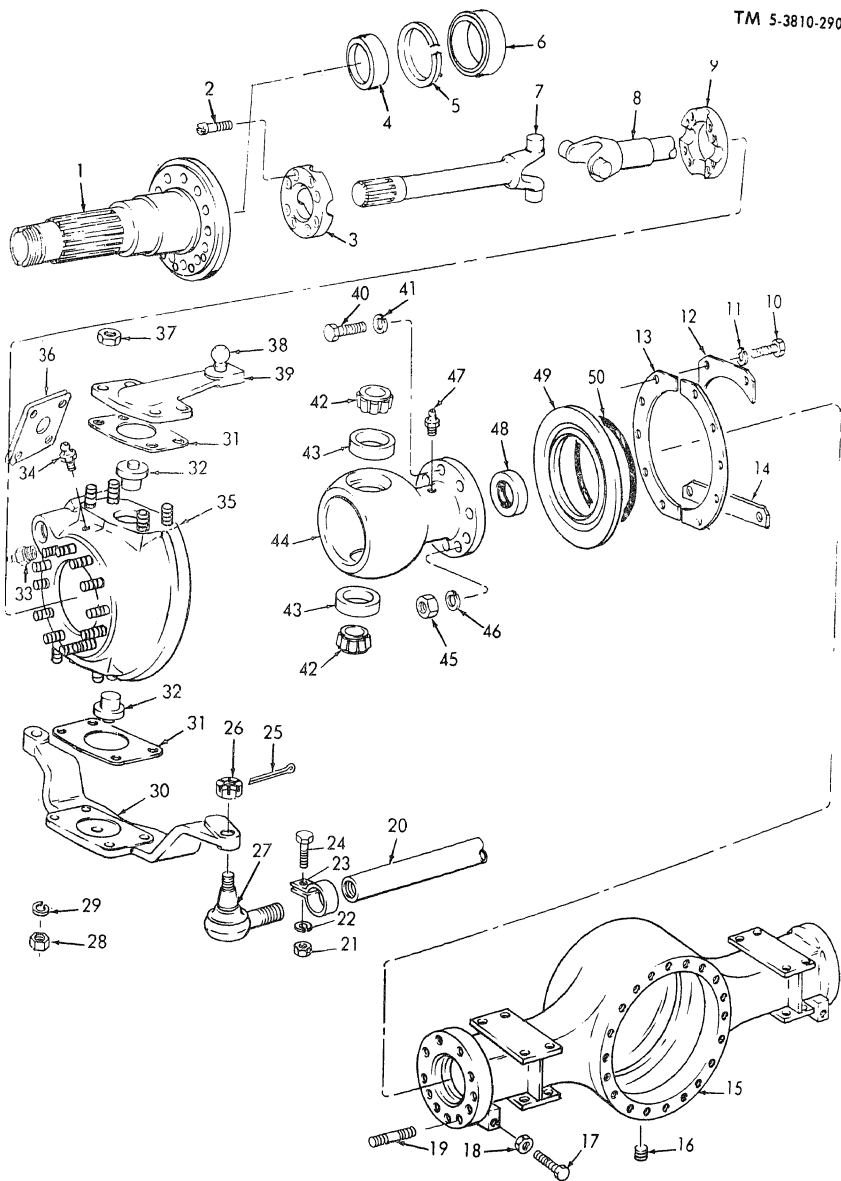
f. *Alignment Specifications.* Stable steering and correct turning radius is assured when the following specifications have been checked with accurate instruments after the axles have been installed on the carrier chassis.

- (1) Toe-in ..... 1/16—1/8 inch.
- (2) Camber ..... 1 degree positive.
- (3) King pin inclination .. 8 degrees.
- (4) Caster ..... 2 degrees positive.
- (5) Adjust capscrews (17, fig. 5-16) to provide 26-30 degree turning radius.

#### Key to figure 5-16.

1. Skein
2. Screw (16)
3. Cage (2)
4. Seal, plain
5. Ring, retaining
6. Bearing, ball
7. Axle, outer (2)
8. Axle, inner (2)
9. Cage (2)
10. Capscrew (20)
11. Lockwasher (20)
12. Retainer (4)
13. Seal retainer (4)
14. Retainer, seal
15. Housing, front
16. Plug, pipe
17. Capscrew (2)
18. Nut (2)
19. Stud (22)
20. Tie rod
21. Nut (2)
22. Lockwasher (2)
23. Clamp (2)
24. Capscrew (2)

25. Pin, cotter (2)
26. Nut (2)
27. Socket Assembly
28. Nut, self-locking
29. Lockwasher
30. Arm, tie rod
31. Shim
32. Shaft, shouldered (4)
33. Fitting, lubrication
34. Fitting, relief
35. Socket
36. Cap, top (RH)
37. Nut (16)
38. Stud, ball
39. Arm, steering (LH)
40. Capscrew (2)
41. Lockwasher (2)
42. Cone, bearing (4)
43. Cup, bearing (4)
44. Ball (2)
45. Nut (22)
46. Lockwasher (22)
47. Fitting, lubrication (4)
48. Seal (2)
49. Seal (2)
50. Packing, preformed (2)



## 5-18. General

Each axle houses a differential carrier assembly mounted in a case, and installed in the axle. The carrier assemblies are identical in design, and maintenance instructions are applicable to both front and rear axle assemblies. Each carrier assembly is connected to the transfer case through drive shafts equipped with universal joints.

## 5-19. Differential Carrier Assembly

*a. Removal.*

- (1) Remove axle assembly (para 5-17).
- (2) Remove the wheel hub and planetary drive (para 5-14).
- (3) Remove the brake assembly (para 5-15).
- (4) Remove plug (12, fig. 5-16) and drain lubricant from the axle assembly.
- (5) Tap skein (1) with a soft hammer and remove.
- (6) Pull outer and inner axle assemblies (2, 3, 5, and 6) from each side of the axle assembly.
- (7) Remove 20 capscrews (38, fig. 5-17) and lockwashers (37). Insert two capscrews in the readed holes in the carrier case. Tighten the screws and remove the differential carrier assembly from the axle housing.

*b. Disassembly.*

- (1) Remove two hydraulic lines (64, fig. 5-17), elbows (63) and adapters (65).
- (2) Remove capscrews (9 and 11) and the lock 10 that secure the cylinder nut (2). Remove cylinder nut (2), piston (8), preformed packing (3 and 5), and back-up rings (4 and 6).
- (3) Remove thrust bearing (62), lockout spacer (61), traction lock discs (59 and 60), and inner spacer (58).
- (4) Remove capscrew (11) and lock (29). Remove safety wire and four capscrews (35) from the bearing caps (33 and 34). Remove the bearing caps and bearing locknuts (12 and 288). Remove the differential assembly from the carrier housing (36).
- (5) Remove bearings cups (13 and 27). With a suitable puller, remove bearing cones (14 and 26).
- (6) Remove safety wire, eight capscrews (25) and four capscrews (30) from differential housing. Separate the two halves of the differential housing (15 and 24).
- (7) Remove the four thrust washers (19), pinion gears (20), spider (21), two side gears (22), and thrust washers (23).
- (8) Remove the twelve capscrews (18) and locknuts (16) that secure the ring gear (17) to the differential housing (15).

## NOTE

The ring gear (17) and the pinion shaft (40) are matched items and must be installed as a set.

(9) Remove nut (54), washer (55), and yoke (56) from the pinion shaft (40).

(10) Remove the capscrews (53), lockwashers (52), seal retainer (51), and seal (57). Discard the seal (57).

(11) Insert two ½-13 NC capscrews into the two threaded holes in bearing retainer (49). Tighten the screws to remove the pinion assembly from the carrier housing (36). Remove shims (47 and 48).

(12) Remove the outer bearing cone (45) and spacer (50).

(13) With a suitable puller or press, remove the inner bearing cone (45), and pilot bearing (39), from pinion shaft (40) and remove bearing cups (46) from bearing retainer (49).

(14) Remove nut (31), setscrew (32), plug (43), and oil scoop (42).

(15) Remove fill plug (44) and relief fitting (41) from carrier housing (36).

*c. Cleaning, Inspection, and Repair.*

(1) Clean all parts with an approved cleaning solvent and dry thoroughly with compressed air.

(2) Inspect all gears, pinion shaft, thrust washers, and bearing cups for scoring or excessive wear.

(3) Place bearing cones in their respective cups and rotate by hand to detect roughness or excessive play.

(4) Inspect the tractionlock fiber-faced discs and friction discs for scoring and wearing of fiber facing.

(5) Replace all parts as required.

*d. Assembly.*

(1) Install pilot bearing (39) and inner bearing cone (45) on pinion shaft (40), and bearing cups (46) into bearing retainer (49) with a suitable press.

(2) Install bearing retainer (49), with installed cups, spacer (50), outer bearing cone (45), yoke (56), washer (55), and nut (54), onto the pinion shaft (40). Torque nut (54), to 350—450 pound-feet.

(3) Check the preload on the pinion bearings by securing the bearing retainer in a vise, wrapping a stout cord around the neck of the yoke, and attaching a spring scale to the free end of the cord. The break-away force required to rotate the shaft as indicated on the scale should read between 11—14½ pounds (15—20 inch pounds). If the reading

on the scale is less than 11 pounds, the spacer (50), is too thick; if the reading is greater than 14½ pounds, the spacer must be replaced by a thicker spacer. Grind a thick spacer or replace a thin spacer as required to obtain the desired reading.

(4) Remove the nut (54), washer (55), and yoke (56), to install a new seal (57) and seal retainer (51). Reinstall the nut, washer, and yoke on the pinion shaft. Torque the nut to 350–450 pound-feet.

(5) Install the pinion gear assembly into the carrier housing (36), using shims (47 and 48), capscrews (53), and lockwashers (52). Torque capscrews to 135–145 pound-feet.

#### CAUTION

When installing pinion gear assembly into differential carrier housing, the oil hole provided in the bearing retainer (49), must align with the oil passage of the differential carrier housing.

(6) Install the ring gear (17), on the differential housing (15), and secure with twelve capscrews (18), and locknuts (16). Torque the capscrews to 100–110 pound-feet.

(7) Install the thrust washers (23) and side gears (22) into the two halves of the differential housing (15 and 24).

(8) Lubricate the spider (21). Install the four pinion gears (20) and thrust washer (19) on the spider.

(9) Install the spider assembly in the ring gear side of the differential housing (24) in place and secure with eight capscrews (25) and four capscrews (30). Torque the capscrews to 70–80 pound-feet and secure with safety wire.

(10) Install the bearing cones (14 and 26) and cups (13 and 27) on the differential housing.

(11) Position the differential assembly on the carrier housing (36), and install the bearing caps (33 and 34), bolts (35), and locknuts (12 and 28). Tighten bearing cap bolts and adjust locknuts to provide 0.010 to 0.013 inch backlash between ring gear and pinion.

#### NOTE

Replace a used ring gear and pinion gear when backlash exceeds 0.030–0.035 inch.

(12) Remove pinion gear assembly to provide clearance for checking preload of differential housing bearings. Measure preload as described in paragraph (3) above. Tighten locknuts (12 and 28), equally to provide a preload of 25–50 pound-inches. Reinstall pinion gear assembly, paragraph (5) above.

(13) Again check backlash between ring gear and pinion. If adjustment is necessary, any

tightening of one locknut must be matched by loosening of the opposite lockbolt.

(14) Torque bearing cap bolts (35) to 240–250 pound-feet safety wire. Position lock (29) on bearing cap (34) and secure with capscrew (11). With chalk or scribe mark position of locknut (12) in relation to bearing cap (33).

(15) Install oil scoop (42) and plug (43) in carrier housing. Place a 0.010 inch shim between oil scoop and ring gear, secure oil scoop with setscrew (32) and nut (31). Remove the shim.

(16) Install the tractionlock inner spacer (58) in the differential housing (15).

(17) Install seventeen friction discs (59), and sixteen opposing discs (60), alternately. Install outer spacer (61) and thrust bearing (62).

(18) Install new packing (3 and 5) and back-up rings (4 and 6), in grooves of cylinder nut (2), after making sure that there are no burrs or sharp edges in the packing grooves. Lubricate the packing with clean hydraulic brake fluid and install the piston (8).

#### NOTE

The piston (8), has a small dowel or pin (7), which must align with the pin hole provided in the cylinder nut (2).

(19) Install the cylinder assembly (1) in the locknut (12).

#### NOTE

Tighten cylinder nut until discs are compressed firm. Back-off cylinder nut one (1) full turn, plus amount necessary to align the lock (10) and secure.

(20) Secure cylinder nut (2) and locknut (12) with lock (10) and capscrews (9 and 11).

(21) Install two elbows (63) into cylinder nut (12) and two adapters (65) into carrier housing (36). Install two hydraulic lines (64).

(22) Install bleeder fitting (41) and fill plug (44) in carrier housing.

(23) Test the traction lock system for leaks by connecting a line from the axle traction lock assembly to the power cluster in the carrier. Maximum pressure should not exceed 1200 psi, and minimum pressure should be 650 psi ± 100-0. The pressure should remain constant for 15 minutes.

#### e. Installation.

(1) Apply gasket compound to rim of carrier housing (36) and install the differential carrier assembly in the axle housing, and secure with twenty capscrews (38) and lockwashers (37). Torque capscrews to 80–90 pound-feet.

(2) Install the axle assembly in reverse order of removal.

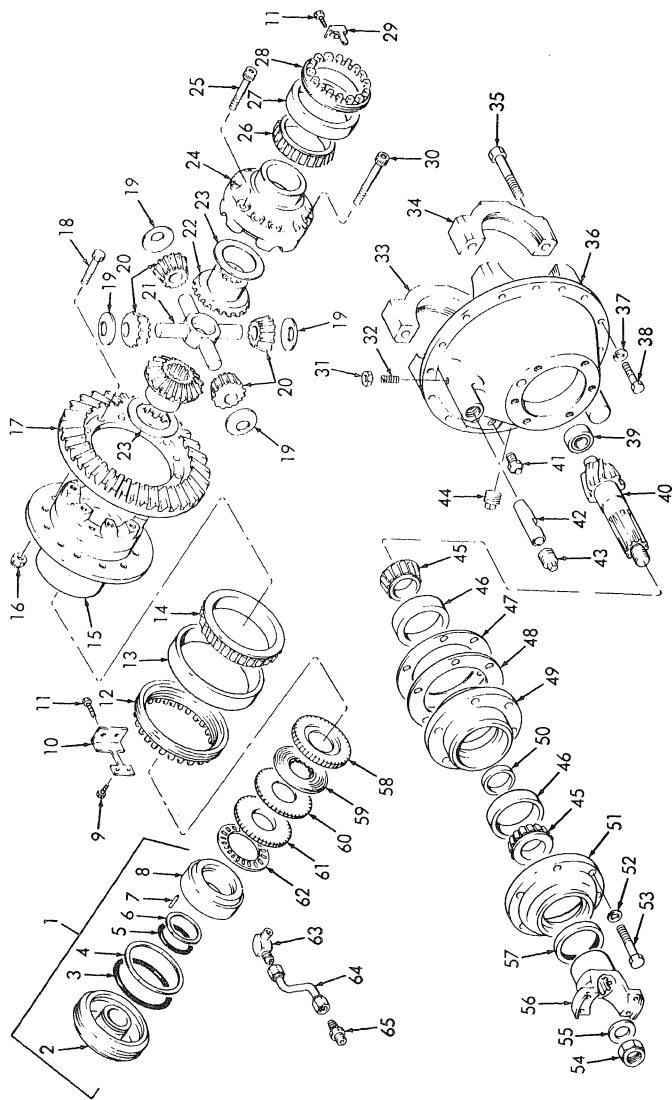


Figure 5-17. Differential carrier assembly components, exploded view.

1. Cylinder assembly
2. Cylinder nut
3. Preformed packing
4. Back-up ring
5. Preformed packing
6. Back-up ring
7. Pin
8. Piston
9. Capscrew
10. Lock
11. Capscrew (2)
12. Locknut
13. Brg. cup
14. Brg. cone
15. Diff. flanged housing
16. Stop nut (12)
17. Ring gear
18. Capscrew (12)
19. Thrust washer (4)
20. Pinion gear (4)
21. Spider
22. Side gear (2)
23. Thrust washer (2)
24. Diff. housing
25. Capscrew (8)
26. Brg. cone
27. Brg. cup
28. Locknut
29. Lock
30. Capscrew (8)
31. Nut
32. Setscrew
33. Brg. cap
34. Brg. cap

35. Capscrew (4)
36. Carrier housing
37. Lockwasher (20)
38. Capscrew (20)
39. Pilot bearing
40. Pinion gearshaft
41. Relief fitting
42. Oil scoop
43. Pipe plug
44. Pipe plug
45. Brg. cone (2)
46. Brg. cup (2)
47. Shim (4)
48. Shim (4)
49. Brg. retainer
50. Spacer
51. Seal retainer
52. Lockwasher (6)
53. Capscrew (6)
54. Locknut
55. Washer
56. Yoke
57. Seal
58. Spacer
59. Friction disc (17)
60. Opposing disc (16)
61. Spacer
62. Thrust bearing
63. Elbow (2)
64. Hydraulic lines (2)
65. Adapter (2)

#### NOTE

Items 17 and 40 serviced as matched set. Items 33, 34, 35, and 36 serviced as matched set.

## Section VI. BRAKE CONTROLS

### 20. General

Several braking controls are installed on the crane as follows:

- a. The foot brake (service) control.
- b. The parking (emergency) brake control and serve air brake control.
- c. Two trailer braking controls, one control valve mounted on the steering wheel column, and other control (trailer parking) mounted on the instrument panel.
- d. The traction lockout control valve, also mounted on the instrument panel.

### 21. Foot Treadle Valve (Service Brake) Assembly

#### a. Removal.

- (1) Tag and disconnect all supply and delivery lines from treadle valve.
- (2) Remove three capscrews (36, fig. 5-18) and lockwashers (37) that secure the valve assembly to the treadle assembly.

### CAUTION

Do not let valve assembly drop to floor when removing capscrews (36).

(3) Remove three capscrews (35), lockwashers (38), and nuts (39). Lift treadle assembly from floor of cab.

#### b. Disassembly.

(1) Remove roll pin (33), collar (32), and pin (5) that anchor the treadle (3) to mounting plate (29).

(2) Remove cotter pin (2), and remove pin (11), and roller (4), from treadle (3).

(3) Lift plunger (34) and boot (31) from mounting plate and separate.

(4) Use a suitable punch or blunt screwdriver and remove the rubber stop (30) from mounting plate (29).

(5) Straighten tang of retainer (28) and remove retainer and piston assembly from valve body (17). Remove spring (21) from valve body.



(6) Remove capscrew (27) that secures washer (26), spring seat (25), and rubber spring (24), to piston assembly (22). Remove preformed packing (23) from piston assembly.

(7) Remove retaining ring (20) and lift exhaust check valve seat assembly from valve body.

(8) Remove machine screw (19) that secures the washer (18), diaphragm (17), and spring (16), to exhaust check valve seat (15). Remove preformed packing (14) from seat.

(9) Lift spring (13), from valve body (7), and remove washer (12) and inlet and exhaust valve assembly (10). Remove preformed packing (11) from valve assembly (10).

(10) Remove plugs (6, 8, and 9) as necessary to facilitate cleaning and inspection of body.

*c. Cleaning, Inspection, and Repair.*

(1) Clean all metal parts with an approved cleaning solvent and dry with compressed air. Clean the boot (31), spring (24), and diaphragm (17) with a damp cloth and dry thoroughly.

(2) Inspect all parts for wear, cracks, scratches, or damage.

(3) Check pliability of rubber components, the boot, rubber spring, and diaphragm.

(4) Replace any part that is damaged in any way or shows signs of excessive wear.

*d. Assembly.*

(1) Assembly of the foot treadle valve assembly can be performed by reversing the instructions for disassembly in paragraph *b* above, with the following special instructions.

(2) Replace all preformed packings with new packings.

(3) A drop of lubricant on the mating surfaces of the stop (30) and mounting plate (29), will ease the insertion of the stop.

(4) Be sure that the springs (13 and 21) are seated properly, and operate freely.

(5) Lightly lubricate the pins (1 and 5), the plunger (34), and the mounting plate (29), before reassembly.

(6) If the tangs of retainer (28), do not readily grasp the body (7), replace the retainer.

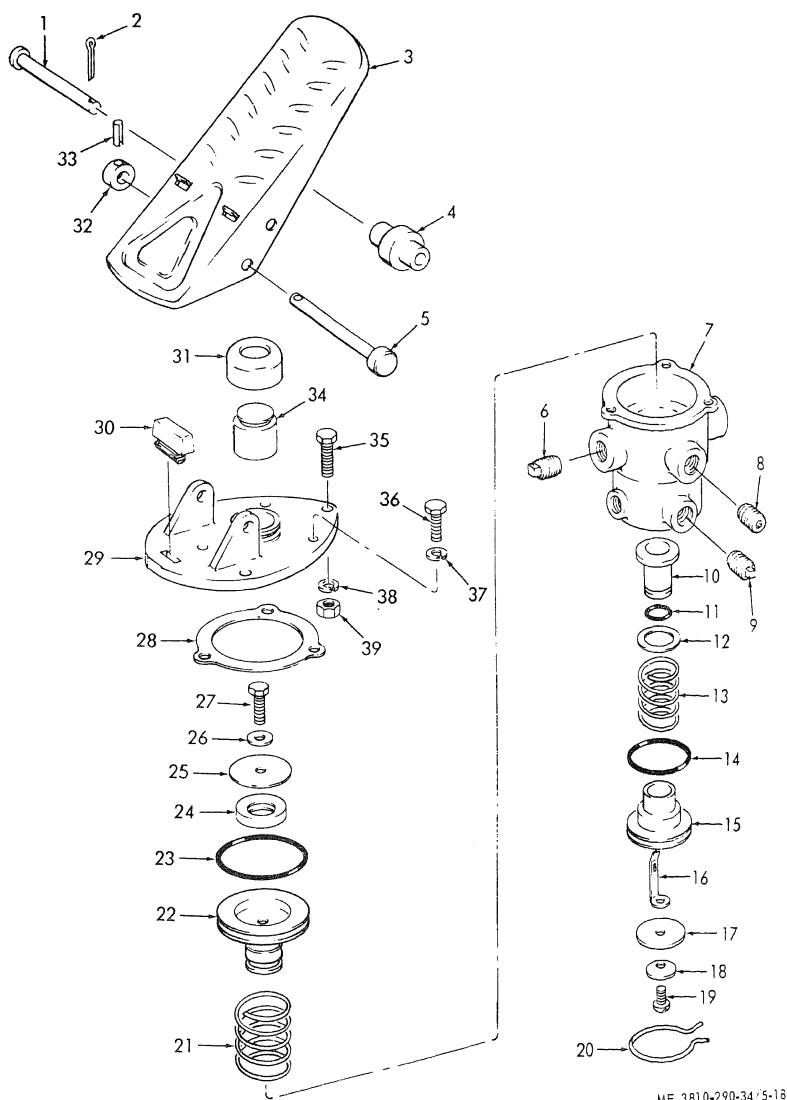
*e. Installation.*

(1) Install the foot treadle valve assembly in reverse of instructions in paragraph *a* above.

(2) Torque mounting bolts in accordance with standard bolt and nut torque data (refer to TM 5-3810-290-12).

KEY to figure 5-18.

1. Pin
2. Cotter pin
3. Treadle
4. Roller
5. Pin
6. Pipe plug
7. Body
8. Pipe plug
9. Pipe plug
10. Valve assembly
11. Preformed packing
12. Washer
13. Spring
14. Preformed packing
15. Seat
16. Spring
17. Diaphragm
18. Washer
19. Screw
20. Retaining ring
21. Spring
22. Piston assembly
23. Preformed packing
24. Rubber spring
25. Seat
26. Washer
27. Capscrew
28. Retainer
29. Mounting plate
30. Stop
31. Boot
32. Collar
33. Roll pin
34. Plunger
35. Capscrew
36. Capscrew
37. Lockwasher
38. Lockwasher
39. Nut



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Figure 5-18. Foot treadle valve (service brake) assembly, exploded view.

## 5-22. Emergency Brake (Parking) and Reserve Air Valve Assemblies

### a. Removal.

(1) Disconnect the air lines to the emergency brake and reserve air valves and remove any tube elbows or adapters from the valves.

(2) Remove the roll pin (21, fig. 5-19) that secures the knob (22), to the operating shaft (18).

(3) Remove nut (20), and dial (19), and remove valve from mounting bracket in cab.

### b. Disassembly.

(1) Remove nut (29).

(2) Remove two machine screws (26) and lockwashers (25), and separate the two body halves. Discard the preformed packing (14).

(3) Push the spool (27) from the lower body (24) and remove preformed packings (17 and 28).

(4) Remove the valve (23) from the shaft (18).

Fit the shaft from the upper body (15) and remove the preformed packing (17).

(5) Remove the spring (16) from the body (15).

### c. Cleaning, Inspection, and Repair.

(1) Clean all parts in an approved cleaning solvent. Dry thoroughly with compressed air.

(2) Inspect the shaft (18), spool (27), and internal surfaces of the valve bodies (15 and 24), for scoring. Use a fine lapping stone or fine crocus paper to remove scoring.

(3) Replace parts that show signs of damage or excessive wear or scoring.

### d. Assembly.

(1) Replace all preformed packings.

(2) Replace the valve (23).

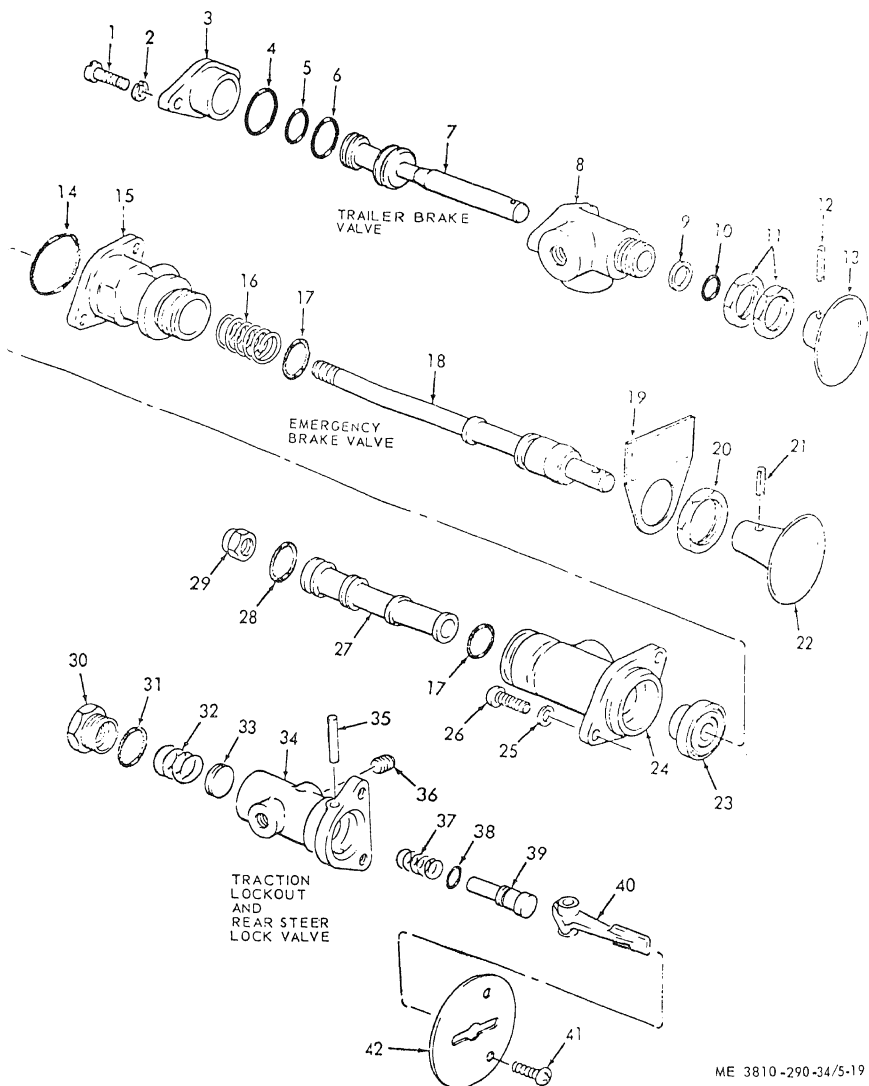
(3) Assemble the valve assembly in reverse order of disassembly described in paragraph b above.

(4) Torque the nut (29) to 30—40 pound-inches in final assembly.

e. *Installation.* Install the emergency brake valve assembly in reverse of instructions in paragraph a above.

### KEY to figure 5-19.

1. Screw
2. Lockwasher
3. Cap
4. Preformed packing
5. Preformed packing
6. Preformed packing
7. Shaft
8. Body
9. Preformed packing
10. Preformed packing
11. Nut (2)
12. Roll pin
13. Knob
14. Preformed packing
15. Body
16. Spring
17. Preformed packing
18. Shaft
19. Dial
20. Nut
21. Roll pin
22. Knob
23. Valve
24. Lower body
25. Lockwasher
26. Screw
27. Spool
28. Preformed packing
29. Nut
30. Spring retainer
31. Preformed packing
32. Spring
33. Valve
34. Body
35. Pin
36. Pine plug
37. Spring
38. Preformed packing
39. Plunger
40. Lever
41. Screw
42. Dial



## 5-23. Trailer Braking Control Valve

*a. Removal.* Disconnect two air lines from valve body, and remove two capscrews (37, fig. 5-20), and lockwashers (38), to remove valve assembly from steering column.

### *b. Disassembly.*

(1) Remove two machine screws (36), and lockwashers (39), that secure the left hand bracket (35). Remove right hand bracket in similar manner.

(2) Remove hand lever (15), by removing acorn nut (17), and lockwasher (16).

### NOTE

Position of hand lever (15), in relation to shaft (14), must be marked for proper assembly.

(3) Remove four acorn nuts (17), and lockwashers (16), and separate valve into four sub-assemblies. Remove studs (18), from inlet cover (34).

(4) Remove and discard preformed packings (30), from valve cage assembly. Depress spring (29), and remove nut (33), discarding valve disc (32), discharge valve (28), and spring (29).

(5) Remove bearing (11), and spacer (10), from piston assembly.

(6) Remove piston assembly from body (27), discarding the spring (1), preformed packing (3), and vee block packing (2) from piston.

(7) Depress the piston cup (8), and remove the retaining ring (9). Carefully release and remove the piston cup (8), spring (6), shims (7 and 5), from piston (4).

(8) Remove retaining ring (26), to remove filter (24), and filter screens (23 and 25), from body (27).

(9) Remove setscrew (22), and plunger (20), discarding spring (21).

(10) Remove nut (19), and press shaft (14), up and out of cam (12), and cover (13).

### NOTE

Position of cam (12) in relation to shaft (14) must be noted and marked for proper reassembly.

### *c. Cleaning, Inspection, and Repair.*

(1) Clean all parts in an approved cleaning solvent and dry with compressed air.

(2) Inspect all parts for cracks, excessive wear or damage. Replace cracked, or damaged parts. If piston (4), or body (27) show signs of excessive wear, replace entire valve.

### *d. Assembly.*

(1) Assembly of the trailer braking control valve is essentially the reverse of paragraph *b* above, with the following special instructions.

(2) Be sure, when assembling shaft (14), to cam (12), that they are alined as marked upon disassembly.

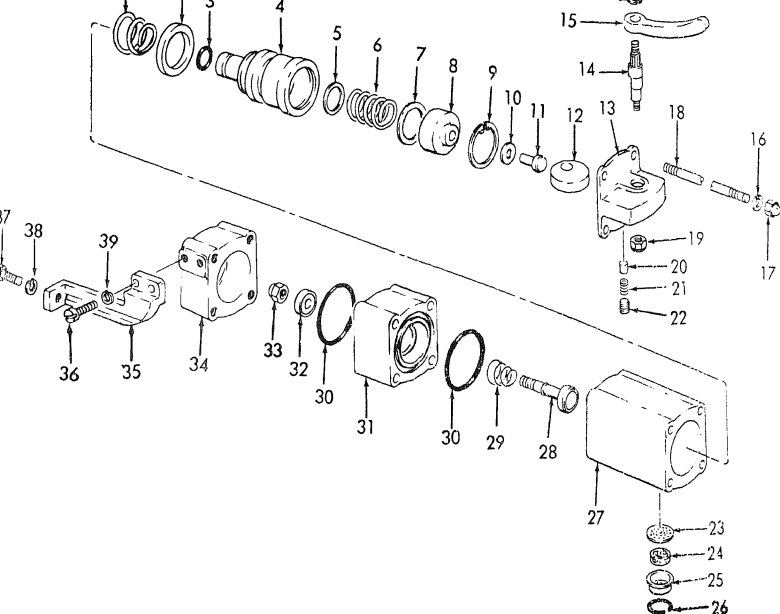
(3) All parts discarded during disassembly are to be replaced with new parts available in repair parts kit, number RN-10-AS.

(4) Torque the four nuts (17), that secure the cover (13), body assembly (27), valve cage assembly (31), and inlet cover (34), in accordance with standard bolt and nut torque data (refer to TM 5-3810-290-12).

### *e. Installation.*

(1) Position the valve assembly on the steering column and secure with two capscrews (37), and lockwashers (38).

(2) Connect the air inlet and supply lines to the valve parts.



ME 3810-290-34/5-20

1. Spring
2. Block vee
3. Preformed packing
4. Piston
5. Shim
6. Spring
7. Shim
8. Piston cup
9. Retainer ring
10. Spacer
11. Plunger bearing
12. Cam
13. Cover
14. Shaft
15. Hand lever
16. Lockwasher
17. Nut
18. Stud
19. Nut
20. Plunger

21. Spring
22. Setscrew
23. Screen filter
24. Filter
25. Screen filter
26. Retainer ring
27. Body
28. Discharge valve
29. Spring
30. Preformed packing
31. Valve cage
32. Valve disc
33. Nut
34. Inlet cover
35. Bracket
36. Screw
37. Capscrew
38. Lockwasher
39. Lockwasher

Figure 5-20. Trailer braking control valve, exploded view.

## 5-24. Trailer Brake (Parking) Valve Assembly

### *a. Removal.*

(1) Provide access to the rear of the instrument panel, by removing the cab assembly.

(2) Disconnect the two air lines from the valve assembly and remove the tube elbows from the valve parts.

(3) Remove roll pin (12, fig. 5-19) that secures the knob (13) to the operating shaft (7).

(4) Remove one nut (11) and pull the valve assembly from the rear of the instrument panel.

### *b. Disassembly.*

(1) Remove the second nut (11), from the valve body (8).

(2) Remove the two machine screws (1), and lockwashers (2), that secure the cap (3), to the valve body. Remove and discard preformed packing (4).

(3) Push the operating shaft (7), out the bottom of the valve body (8), and remove packings (5 and 6).

(4) Remove packings (9 and 10), from body.

### *c. Cleaning, Inspection, and Repair.*

(1) Clean all parts with an approved cleaning solvent, and dry with compressed air.

(2) Check all parts for wear or damage.

(3) Replace worn or damaged parts.

*d. Assembly.* Assemble the valve assembly in reverse of disassembly as instructed in *b* above, inserting all new packing.

*e. Installation.* Install the valve assembly in reverse of instructions in paragraph *a* above.

## 5-25. Traction Lockout and or Rear Steer Lock Valve Assembly

### *a. Removal.*

(1) Disconnect the two air lines from the valve assembly.

(2) Remove two machine screws (41, fig. 5-19), and dial (42), from the valve assembly.

(3) Remove valve assembly from the rear of the instrument panel.

### *b. Disassembly.*

(1) Remove spring retainer (30), and discard preformed packing (31).

(2) Remove spring (32), and valve (33), from valve body (34).

(3) Press pin (35), from body (34), and cam lever (40).

(4) Remove lever (40), plunger (39), and spring (37), from body.

(5) Discard preformed packing (38).

(6) Remove pipe plug (36).

### *c. Cleaning, Inspection, and Repair.*

(1) Clean all parts with an approved cleaning solvent. Dry thoroughly with compressed air.

(2) Check mating surfaces of plunger (39) and valve (33) for scoring. Minor scoring can be removed by lapping with a fine stone or crocus paper.

(3) Check cam surfaces of lever (40) and head of plunger for excessive wear.

(4) Replace any damaged or badly worn parts.

### *d. Assembly.*

(1) Replace preformed packings (31 and 38).

(2) Lightly lubricate the valve (33), plunger (39), and cam of lever (40) before assembly.

(3) Assemble valve in reverse of instructions in paragraph *b* above.

(4) Check to be sure springs are properly seated and functioning correctly.

*e. Installation.* Install valve assembly by reversing the instructions of paragraph *a* above.

## Section VII. BRAKE CHAMBERS

### 5-26. General

The rear and front air brake chambers operate in the air system in a similar manner, and perform the dual function of service braking and braking for parking. Both front and rear chambers are a dual-diaphragm unit. The same maintenance instructions are generally applicable.

### 5-27. Front Air Brake Chamber

#### *a. Removal.*

(1) Refer to TM 5-3810-290-12 for removal instructions of the front air brake chamber.

(2) Remove four capscrews and lockwashers to remove mounting bracket from axle socket.

#### *b. Disassembly.*

#### NOTE

Before removal of yoke (9, fig. 5-21), from rod (11), note the measurement from base of air chamber to yoke. Upon assembly lock the yoke in this same relative position.

(1) Loosen jam nut (10), and remove yoke (9), from rod (11).

(2) Loosen carriage bolts (1), and remove clamps (2).

(3) Remove the nonpressure plate (4), and diaphragm (5).

(4) Loosen carriage bolts (1) and remove clamps (7). Remove intermediate body (6), diaphragm separator (21), and diaphragm (8).

(5) Lift out push rod (20), and separate from rod (11).

(6) Lift spring (19) from air chamber body (18).

*c. Cleaning, Inspection, and Repair.*

(1) Clean all parts with an approved cleaning solvent and dry with compressed air.

(2) Inspect parts for dents, cracks, burs, and sharp edges that might damage diaphragms.

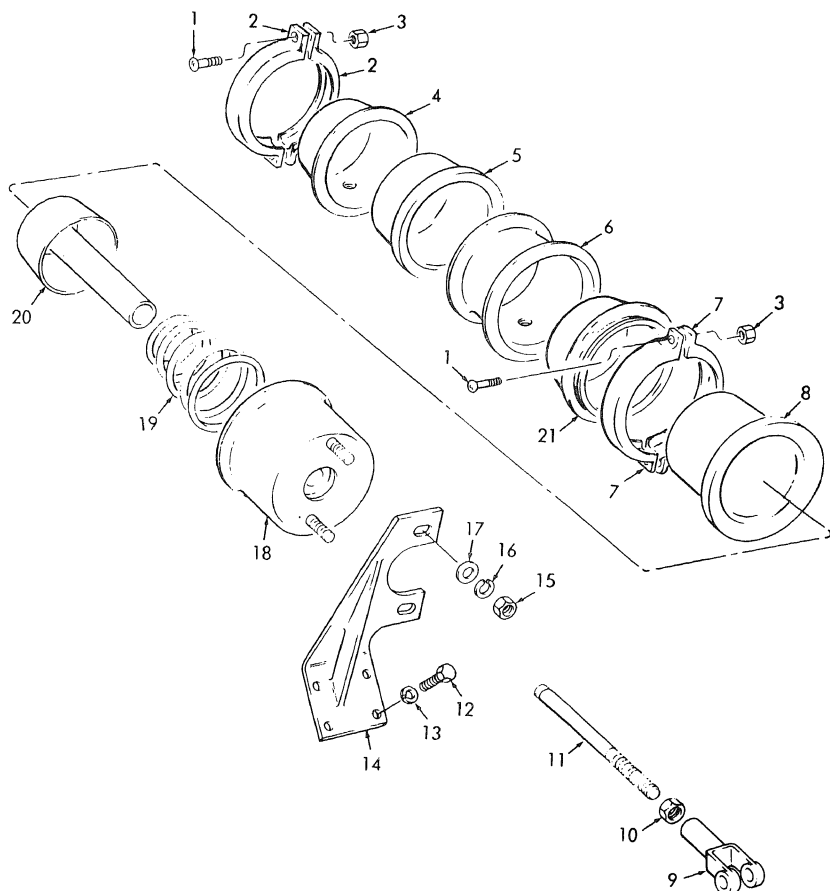
(3) Check threads of rod (11), and yoke (9), for damage.

(4) Remove any burs and break sharp edges found. Replace a part that is dented, cracked, or otherwise damaged.

*d. Assembly.* Assemble the front air brake chamber in reverse of disassembly. Install new diaphragms (5 and 8).

*e. Installation.* Refer to TM 5-3810-290-12 and install the front air brake chamber.





ME 3810-290-34/5-21

1. Carriage bolt (4)
2. Clamp
3. Nut (4)
4. Nonpressure plate
5. Diaphragm
6. Intermediate body
7. Clamp
8. Diaphragm
9. Yoke
10. Nut
11. Rod

12. Capscrew (4)
13. Lockwasher (4)
14. Bracket
15. Nut (2)
16. Lockwasher (2)
17. Washer
18. Body
19. Spring
20. Push rod
21. Diaphragm

Figure 5-21. Front air brake chamber and mounting details, exploded view.

**528. Rear Air Brake Chamber****a. Removal.**

(1) Refer to TM 5-3810-290-12 for removal instructions of the rear air brake chamber.

(2) Remove the air chamber mounting bracket in the same manner as instructed for the front air chamber mounting bracket.

**b. Disassembly.****NOTE**

Before removal of yoke (33, fig. 5-221, from rod (31), note the measurement from base of air chamber to yoke. Upon assembly lock the yoke in this same relative position.

(1) Loosen jam nut (32), and remove yoke (33), from rod (31).

(2) Remove boot (29).

(3) Loosen capscrews (2), and remove clamp (1).

(4) Loosen capscrews (2), and remove clamp (7). Remove service pressure plate (6) and diaphragm (8).

**CAUTION**

Remove clamp (7), carefully. Diaphragm (8) is under high spring tension.

(5) Lift out assembled shaft (9) and push rod (31). Separate shaft and rod only if replacement is required.

(6) Lift spring (10) from non-pressure plate (12).

**NOTE**

Further disassembly of the non-pressure plate components (11 through 26), is not practical.

**c. Cleaning, Inspection and Repair.**

(1) Clean all metal parts with an approved cleaning solvent and dry thoroughly. Clean boot and diaphragms with damp cloth.

(2) Inspect parts for dents, cracks, burs, and sharp edges that might damage diaphragms.

(3) Check threads of rod (31) and yoke (33) for damage.

(4) Remove any burs and break sharp edges found. Replace a part that is dented, cracked, or otherwise damaged.

**d. Assembly.**

(1) Assemble the rear air brake chamber in reverse of instructions for disassembly.

(2) When installing diaphragms (5 and 8) make certain the lip of each is well seated on rims of non-pressure plate (12), service pressure plate (6) and auxiliary pressure plate (4).

(3) Tighten clamps (1 and 7) firmly.

**e. Installation.** Refer to TM 5-3810-290-12 and install the rear air brake chamber.

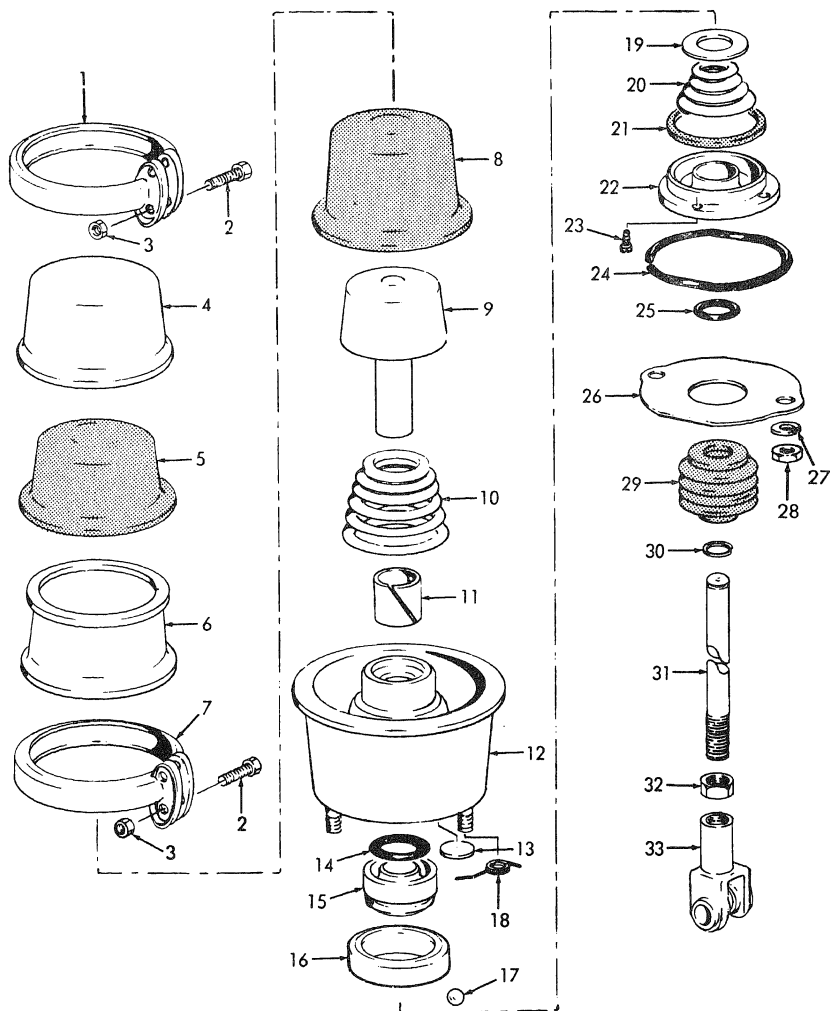


Figure 5-22. Rear air brake chamber, exploded view.

KEY to figure 5-22.

1. Clamp
2. Capscrew (4)
3. Nut (4)
4. Auxiliary pressure plate
5. Diaphragm
6. Service pressure plate
7. Clamp
8. Diaphragm
9. Shaft
10. Spring
11. Bearing
12. Non-pressure plate
13. Washer
14. Preformed packing
15. Piston
16. Collar

17. Ball (8)
18. Spring
19. Washer
20. Spring
21. Preformed packing
22. Cap
23. Screw (4)
24. Preformed packing
25. Preformed packing
26. Splash guard
27. Lockwasher (2)
28. Nut (2)
29. Boot
30. Retaining ring
31. Push rod
32. Nut
33. Yoke

## Section VIII. STEERING SYSTEM COMPONENTS

### 5-29. General

a. The front wheel steering is provided by a mechanical cam-and-lever unit controlled by the steering wheel and connected to a power steering control valve and drag link assembly. The control valve regulates the hydraulic fluid to the hydraulic steering cylinders which provide the larger portion of turning torque required for steering.

b. The rear wheel steering is fully hydraulic. Control of the steering is effected by an instrument panel-mounted rear steer control valve, while the steering power is supplied by a hydraulic steering cylinder. A mechanical, air-operated locking device locks the rear axle in its normal position when rear steering is not required.

### 5-30. Front Steering Control Valve

a. *Removal.* Refer to TM 5-3810-290-12 and remove the front steering control valve.

b. *Disassembly.*

(1) Remove lube fittings (12, fig. 5-23) from valve housing (11) and drag link (18).

(2) If not completely removed upon removal of the unit, remove the socket plug (4), plug washer (5), spring (6), and both ball seats (7) from the valve socket assembly.

(3) Remove end plug (33), spacer (32), spring (31), ball seats (30), and seat (29) from the drag link.

(4) Loosen capscrew (19) and clamp (20) to permit separation of the drag link (18), and the valve assembly.

(5) Remove adapter (21), and lockring (22), from valve housing (11).

(6) Remove two locknuts (8) from spool ends.

(7) Remove socket bearing (9) from socket (10), from valve body.

(8) Pull spool assembly from valve housing removing the washer (23), reaction ring (25) spring (26), and spacer (27) from the spool (13).

(9) Lift the gland (15) and valve body (17) from valve housings (11), and discard preformed packing (16).

c. *Cleaning, Inspection, and Repair.*

(1) Clean all parts with an approved cleaning solvent and dry thoroughly with compressed air.

(2) Inspect all parts for wear, cracks, scoring or other signs of damage.

(3) Replace any part that shows signs of wear or other damage.

#### NOTE

The spool (13) and valve body (17) must be replaced as a matched set.

d. *Assembly.*

(1) Assembly is essentially the reverse of paragraph b above, with the following special instructions.

(2) Replace all packings and install a new locking (22).

(3) Lightly lubricate all parts with hydraulic fluid before assembly, to ease assembly and provide better seals at packings.

(4) Torque the locknuts (8), to 20—25 pound-feet.

e. *Installation.* Install the front steering control valve and drag link (refer to TM 5-3810-290-12).

### 5-31. Front Hydraulic Steering Cylinder

a. *Removal.* Remove the front hydraulic steering cylinder (refer to TM 5-3810-290-12).

b. *Disassembly.*

(1) Loosen capscrew (28, fig. 5-24) and remove ball stud and socket assembly (29) from operating rod (16).

(2) Remove cotter pin (2), that locks end plug (1), in place.

(3) Remove end plug (1), spring (3), ball stud (7), and ball seats (4), from cylinder body (6).

(4) Remove capscrews (27), lockwashers (26), and end cap (25).

(5) Push head (22), into body (6) sufficiently to remove ring (23). Pull piston-rod-head assemblies from body (6).

(6) Slide head (22) from rod (16), and remove retaining ring (19), washer (20), seal (21), wiper and retaining ring (18).

(7) Remove locknut (10), piston followers (12), packings (14), U-cups (13), and piston (15), from rod (16).

#### NOTE

DO NOT remove retainer rings (11), unless rings require replacement.

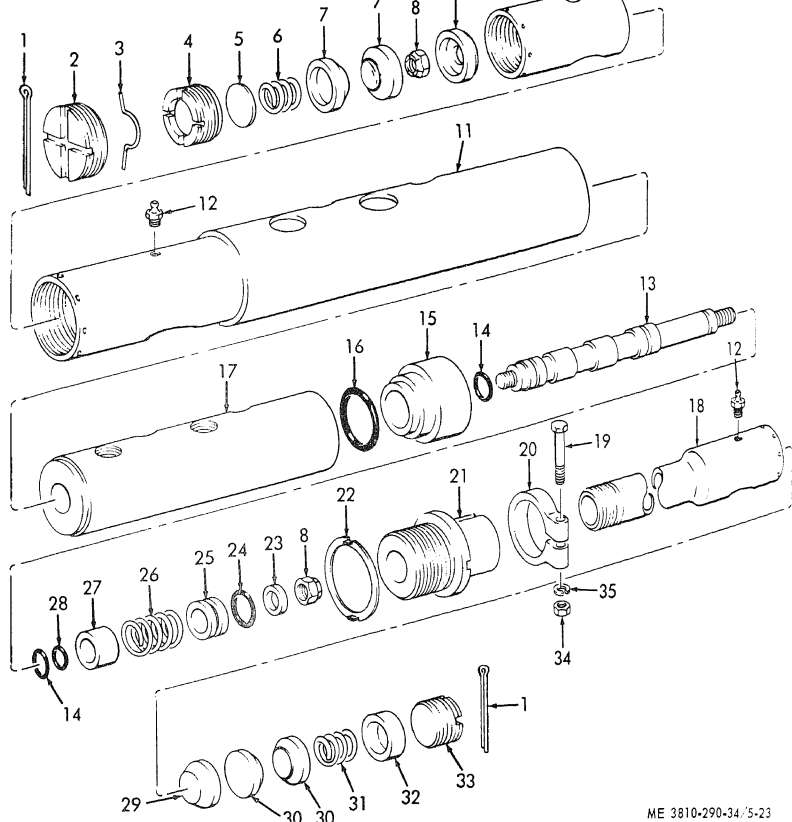
#### c. *Cleaning, Inspection and Repair.*

(1) Clean all parts in an approved cleaning solvent and dry thoroughly with compressed air.

(2) Inspect ball stud (7) and ball seats (4) for scoring or pitting. Replace parts that are pitted or badly scored.

(3) Inspect bore of head (22) and rod (16) for scoring, scratches, out-of-roundness, and other damage. Replace a badly worn or damaged rod and head. Light scoring can be removed with fine crocus paper.

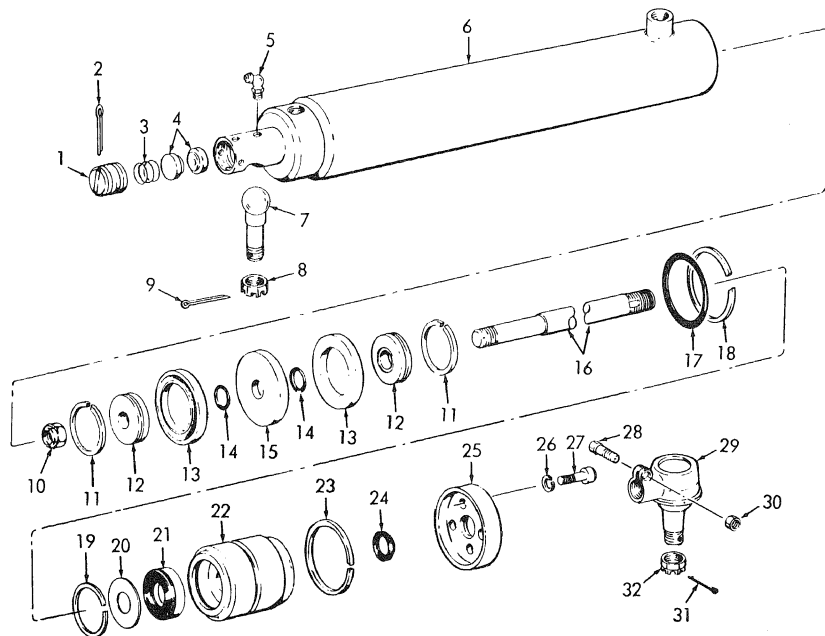
(4) Inspect piston (15) for scoring, pitting, and other damage. Remove any burs and break sharp edges found. Replacement of the piston is necessary only if scoring or pitting is excessive.



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- |                        |                       |
|------------------------|-----------------------|
| 1. Cotter pin          | 19. Capscrew          |
| 2. End plug            | 20. Clamp             |
| 3. Plug lock           | 21. Adapter           |
| 4. Ball socket plug    | 22. Lockring          |
| 5. Plug washer         | 23. Washer            |
| 6. Spring              | 24. Preformed packing |
| 7. Ball seat           | 25. Reaction ring     |
| 8. Locknut             | 26. Spring            |
| 9. Ball socket bearing | 27. Spacer            |
| 10. Ball socket        | 28. Preformed packing |
| 11. Valve housing      | 29. Seat              |
| 12. Lube fitting       | 30. Ball seat         |
| 13. Spool              | 31. Spring            |
| 14. Preformed packing  | 32. Spacer            |
| 15. Gland              | 33. End plug          |
| 16. Preformed packing  | 34. Nut               |
| 17. Valve body         | 35. Lockwasher        |
| 18. Drag link          |                       |

Figure 5-23. Front steering control valve and drag link assembly, exploded view.



ME 3810-290-34/5-24

1. End plug
2. Cotter pin
3. Spring
4. Seat (2)
5. Lubrication fitting
6. Body
7. Ball stud
8. Nut
9. Cotter pin
10. Nut
11. Retainer ring
12. Piston follower (2)
13. U-cup (2)
14. Packing (2)
15. Piston
16. Rod

17. Packing
18. Retainer ring
19. Retainer ring
20. Washer
21. Seal
22. Head
23. Ring
24. Wiper
25. End cap
26. Lockwasher
27. Capscrew
28. Capscrew
29. Ball stud and socket assembly
30. Nut
31. Cotter pin
32. Nut

Figure 5-24. Front hydraulic steering cylinder, exploded view.

(5) Inspect the bore of the cylinder body (6). Replace the body if it is found to be out-of-round, scored, or damaged in any way.

*d. Assembly.*

(1) Assemble the hydraulic steering cylinder in reverse order of disassembly.

(2) Use new rings (18 and 19), packings (14)

when assembling cylinder.

(3) When installing the end plug (1) tighten the plug down solidly, then back off  $\frac{1}{4}$ — $\frac{1}{2}$  turn to align slot in plug with holes in body for cotter pin (2).

*e. Installation.* Install the hydraulic steering cylinder (refer to TM 5-3810-290-12).

### 5-32. Rear Hydraulic Steering Cylinder

*a. Removal.* Remove the rear hydraulic steering cylinder (refer to TM 5-3810-290-12).

#### *b. Disassembly.*

(1) Loosen capscrew (25, fig. 5-25), and remove ball stud and socket assembly from operating rod (16).

(2) Remove cotter pin (2) that locks end plug (1), in place.

(3) Remove end plug (1), spring (3), ball stud (7), and ball seats (4), from cylinder body (6).

(4) Remove capscrews (24), lockwashers (23) and end cap (22).

(5) Push head (19) into body (6) sufficiently to remove the three-section ring (20). Pull piston-rod-head assemblies from body (6).

(6) Slide head (19), from rod (16), and remove packing (17), retaining ring (18), and seal (21).

(7) Remove locknut (10), piston followers (12), packings (14), U-cups (13), and piston (15) from rod (16).

#### NOTE

DO NOT remove retainer rings (11) unless rings require replacement.

(1) Clean all parts in an approved cleaning solvent and dry thoroughly with compressed air.

(2) Inspect ball stud (7), and ball seats (4), for scoring or pitting. Replace parts that are pitted or badly scored.

(3) Inspect bore of head (19) and rod (16) for scoring, scratches, out-of-roundness, and other damage. Replace a badly worn or damaged rod and head. Light scoring can be removed with fine crocus paper.

(4) Inspect piston (15), for scoring, pitting and other damage. Remove any burs and break sharp edges found. Replacement of the piston necessary only if scoring or pitting is excessive.

(5) Inspect the bore of the cylinder body (6). Replace the body if it is found to be out-of-round, scored, or damaged in any way.

#### *d. Assembly.*

(1) Assemble the hydraulic steering cylinder in reverse order of disassembly.

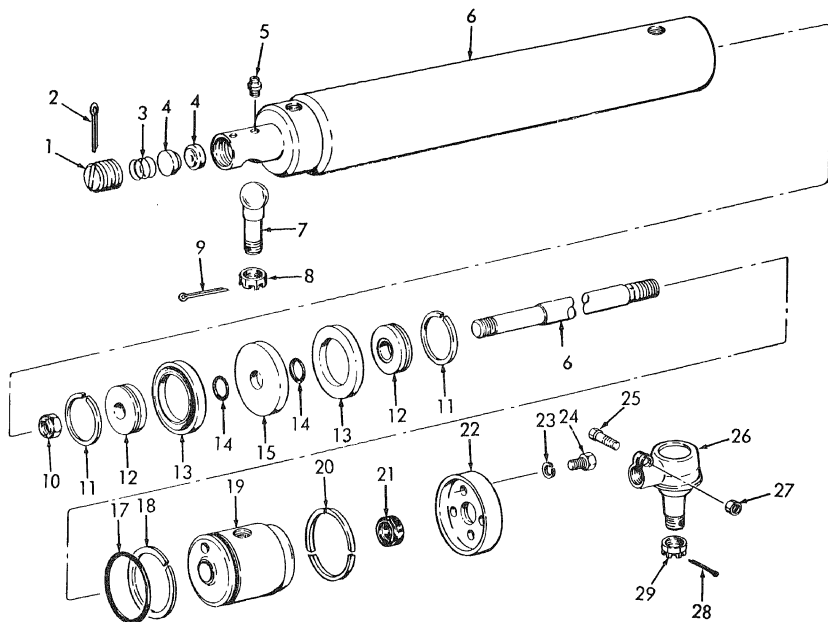
(2) Use new ring (18), packings (14 and 17) U-cups (13), and seal (21), when assembling cylinder.

(3) When installing the end plug (1), tighten the plug down solidly, then back off  $\frac{1}{4}$ — $\frac{1}{2}$  turn to align slot in plug with holes in body for cotter pin (2).

(4) Check alignment of threaded port in head (19) to hole provided in body (6).

*e. Installation.* Install the hydraulic steering cylinder (refer to TM 5-2810-290-12).





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1. End plug
2. Cotter pin
3. Spring
4. Seat (2)
5. Lubrication fitting
6. Body
7. Ball stud
8. Nut
9. Cotter pin
10. Nut
11. Retainer ring
12. Piston follower (2)
13. U-cup (2)
14. Packing (2)
15. Piston

16. Rod
17. Packing
18. Retainer ring
19. Head
20. Ring
21. Wiper
22. End cap
23. Lockwasher
24. Capscrew
25. Capscrew
26. Ball stud and socket assembly
27. Nut
28. Cotter pin
29. Nut

Figure 5-25. Rear hydraulic steering cylinder, exploded view.

### 5-33. Rear Steer Control Valve

*a. Removal.* Remove the rear steer control valve from the instrument panel (refer to TM 5-3810-290-12).

*b. Disassembly.*

(1) Remove cotter pin (18, fig. 5-26), pin (19), and handle (17).

(2) Remove screws (16), bracket (20), and cap (23).

(3) Pull assembled spool (2), C-washers (21), spring (21), and packings (1), from the valve body (12). Disassemble components and discard packings.

(4) Remove cap (11), nut (10), gaskets (9), setscrew (8), spacer (7), and relief valve cartridge assembly from body (12). Remove and discard packings (13 and 14).

### c. *Cleaning, Inspection and Repair.*

(3) Inspect bore of body (12) for scoring or thread damage at ports.

(4) Break sharp edges on spool with fine crocus cloth. Replace spool and body if either is scored or damaged in any way.

Spool (2) and body (12) are matched items, and must be replaced as a set.

(5) Inspect all other parts for wear, cracks, or other damage. Replace any part that is worn, cracked or otherwise damaged.

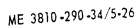
following special instructions.

(3) Install spool (21) by first positioning one preformed packing in the packing groove nearest the neutral spring (22) end of the spool. Insert spool into the rear of body (12), pushing it through just enough to expose the packing groove at the handle end of the spool. Install second packing (1) in groove and push spool back into body to install spring (22) and C-washers (21).

At no time should packings (1), cross sharp edges of cored pockets in body (12).

(4) Complete assembly of valve and set relieve valve at 1800 p.s.i.

e. **Installation.** Refer to TM 5-3810-290-12 and install the rear steer control valve.



1. Packing preformed (2)
2. Spool
3. Ball
4. Spring
5. Spacer
6. Pipe plug
7. Spacer
8. Setscrew

9. Gasket (2)
10. Nut
11. Cap
12. Body
13. Packing, preformed
14. Retainer, packing
15. Sleeve
16. Screw (6)

17. Handle
18. Cotter pin
19. Pin
20. Bracket
21. Washer (2)
22. Spring
23. Cap

5-57

### 5-34. Rear Steer Lock Air Chamber

*a. Removal.* Refer to TM 5-3810-290-12 for instructions on removal of the rear steer lock air chamber.

*b. Disassembly.*

(1) Loosen capscREW (4 fig. 5-27), and remove clamp (3).

(2) Remove cover (1), and diaphragm (5).

(3) Lift push rod (6), and spring (7), from non-pressure plate (10).

*c. Cleaning, Inspection, and Repair.*

(1) Clean all parts with an approved cleaning solvent and dry with compressed air.

(2) Inspect all parts for dents, cracks, burs, and any other damage.

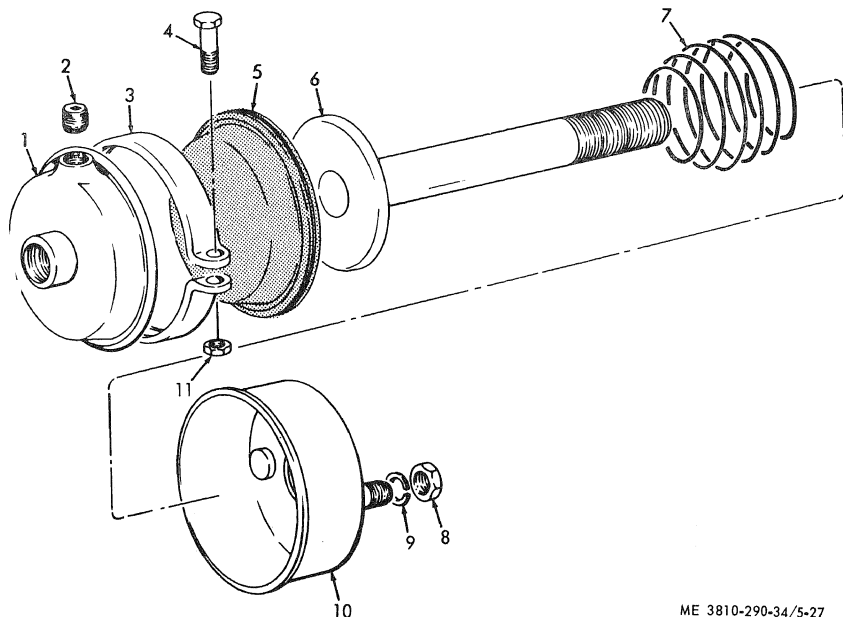
(3) Check threads of push rod (6).

(4) Remove any burs and break all sharp edges found.

(5) Replace any part that is dented, cracked, or badly damaged in any way.

*d. Assembly.* Assemble the rear steer lock air chamber in reverse order of disassembly, installing a new diaphragm (5).

*e. Installation.* Refer to TM 5-3810-290-12 and install the rear steer lock air chamber.



1. Cover
2. Pipe plug
3. Clamp
4. Capscrew
5. Diaphragm
6. Push rod
7. Spring
8. Nut (2)
9. Lockwasher (2)
10. Nonpressure plate
11. Nut

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Figure 5-27. Rear steer lock air chamber, exploded view.

### 5-35. Steering Gear Box

#### a. Removal.

(1) Loosen the clamping bolt on the bottom yoke of universal shaft assembly.

(2) Remove cotter pin and remove control valve from ball stud of steering arm (fig. 5-28).

(3) Remove three nuts (fig. 5-28) that secure the steering gear box to its support bracket.



Figure 5-28. Steering gear box, removal and installation.

#### b. Disassembly.

##### NOTE

Before disassembly, match mark steering arm and shaft so they may be assembled in the same relationship.

(1) Remove nut (16, fig. 5-29), lockwasher (17), capscrew (18), and steering arm (15).

(2) Remove plugs (12 and 20) and drain lubricant.

(3) Remove locknut (1), and setscrew (2).

(4) Remove four capscrews (19), and remove cover (3), and gasket (4).

(5) Remove assembled shaft (22) and bearing assemblies (23). Press bearing assemblies from shaft only if replacement is necessary.

(6) Remove four capscrews (9), cover assembly (10), and shims (11).

(7) Lift out cam (8), and remove seals (6), and bearings (7).

(8) Press seal (14) from housing (5). Remove bushing (13) only if replacement is required.

#### c. Cleaning, Inspection and Repair.

(1) Clean all parts with an approved cleaning solvent and dry thoroughly.

(2) Inspect shaft (22) for scoring or signs of wear. Remove minor scoring with fine crocus cloth. Insert shaft in housing and check for excessive play between shaft and bushing (13). Replace bushing if required.

(3) Inspect bearing assemblies (23) for snug fit in shaft and smooth operation. Inspect cam follower tips of bearing assemblies and cam (8) for cracks and signs of wear. Replace parts as required.

(4) Inspect bearings (7) for pitting and binding. Check operation by rotating bearing by hand. Replace a bearing that does not operate smoothly or is pitted.

(5) Inspect housing and covers for cracks or damaged threads. Replace parts as required.

*d. Assembly.* Assemble the steering gear box in the reverse order of disassembly.

*e. Installation.*

(1) Install the steering gear box in the reverse order of removal.

(2) Install control valve on steering arm ball stud.

*f. Adjustment.*

(1) Loosen locknut (1) and turn setscrew (2) in until a noticeable drag is produced on the steering wheel.

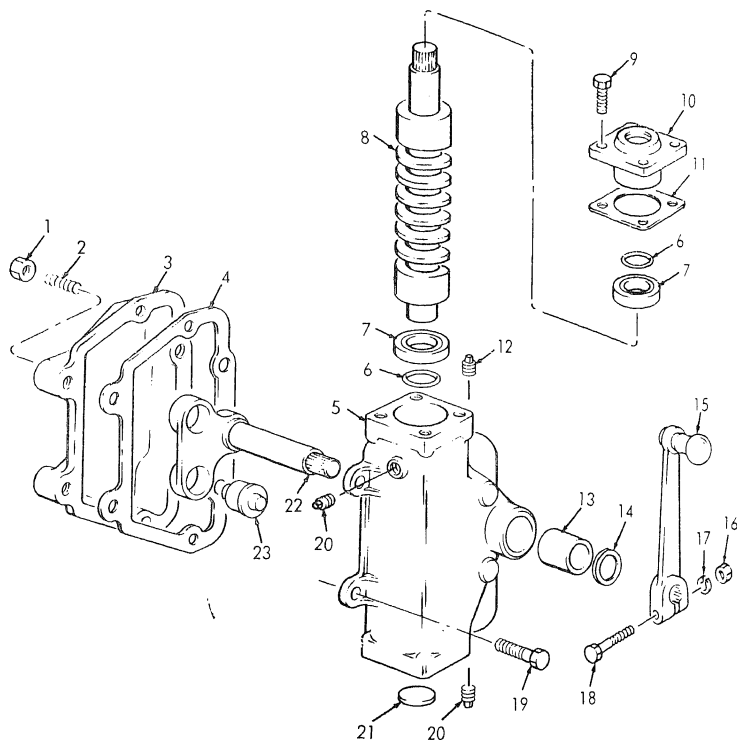
(2) Back off the setscrew,  $\frac{1}{2}$  turn and secure in place with locknut.

NOTE

After considerable vehicle usage, readjustment may be necessary to compensate for wear of cam and follower as may be detected by play in the steering wheel.

KEY to figure 5-29.

1. Locknut
2. Setscrew
3. Cover
4. Gasket
5. Housing
6. Seal (2)
7. Bearing (2)
8. Cam
9. Capscrew (4)
10. Cover assembly
11. Shim
12. Plug, vented
13. Bushing
14. Seal
15. Steering arm
16. Nut
17. Lockwasher
18. Capscrew
19. Capscrew (4)
20. Plug (2)
21. Expansion plug
22. Shaft
23. Bearing assembly (2)



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Figure 5-29. Steering gear box, exploded view.

### 5-36. Speed Sensing Switch and Transmitter

*a. General.* The speed sensing switch is a two station, solid state switch, activated by a transmitter mounted on the transfer assembly. The switch acts as a safety device, by opening and closing different circuits at preset speed ranges and inhibits use of rear steer control and downshift at other than selected speeds.

### *b. Test.*

(1) Test operate with transfer in high-range and transmission in F2.

(a) Downshift inhibitor actuates at 8 miles per hour.

(b) Pull transmission shift lever off F2 position; warning light should illuminate.

(2) Test operate with transfer in low-range and transmission in F2.

(a) Downshift inhibitor actuates at 4 miles per hour.

(b) Pull transmission shift lever off F2 position; warning light should illuminate.

(3) If switch is inoperative check:

(a) Wiring for breaks, shorts and continuity.

(b) Remove the transmitter and drive tank (fig. 5-30).

(c) Install ohmmeter test leads to transmitter contacts and rotate drive tang. Ohmmeter should show two deflections (infinite resistance: approximately 10 ohms resistance) for each revolution.

(d) If wiring and transmitter are free of defects, replace speed sensing switch (fig. 5-30).

c. *Removal.* Refer to figure 5-30 and remove speed sensing switch and transmitter.

d. *Cleaning and Inspection.*

(1) Clear the exterior of all parts with a cloth dampened in an approved cleaning solvent, and dry thoroughly.

(2) Inspect electrical cable for cracked or broken insulation, kinks, or binding. Replace if defective.

(3) Inspect switch and transmitter for breaks and loose mounting.

e. *Installation.* Refer to figure 5-30 and install the speed sensing switch and transmitter.

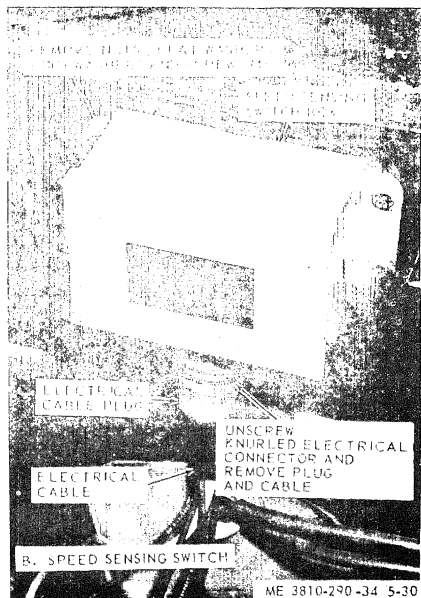
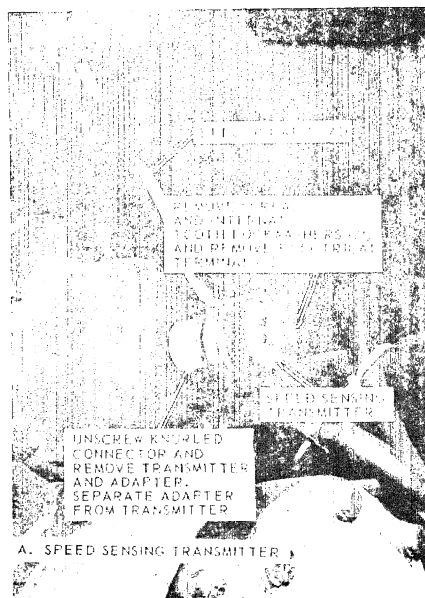


Figure 5-30. Speed sensing switch and transmitter.

## CHAPTER 6

## REPAIR OF CARRIER FRAME AND COMPONENTS

## Section I. CARRIER COMPONENTS

## 6-1. General

The carrier components listed in this chapter are considered to be part of the carrier frame. However, the seat, cab heater, panel wiring hood, fuel tanks, hydraulic reservoir, and fenders are not actually a physical part of the frame. They are mounted to the frame, or to brackets, or other supports which mount to the frame.

## 6-2. Seat Assembly

*a. Removal.* Remove the seat assembly (refer to TM 5-3810-290-12).

*b. Disassembly.*

(1) Remove back cushion assembly (3, fig. 6-1) by removing screws (5).

(2) Remove back frame assembly (9) by removing two nuts (4), pivot pins (6 and 7), and spring (8). Remove spring (10) and disengage handle (11) from ratchet.

(3) Disconnect hose assembly (18), remove elbows (14) and air valve assembly (15).

(4) Remove four capscrews (43) and lift off assembled seat frame and cushion.

(5) Remove four screws (48), lockwashers (49) and seat cushion from frame (12).

(6) Remove handle (45) by removing four screws (46) and lockwashers (47).

(7) Remove two capscrews (38) and nuts (37)

that attach shock absorber (42). Remove sleeve (41) and bushings (40).

(8) Remove palnut (31) and nut (4) from bottom of air spring (25). Remove capscrew (19) and lockwasher (20) from top of air spring and remove the air spring and washer (24).

(9) Remove pins (39) and shafts (36 and 44) separating seat support assembly (16), upper arm assembly (21), lower arm assembly (26), and lower frame assembly (29).

(10) Remove four capscrews (27), washers (28) and track assemblies (32 and 34).

*c. Cleaning, Inspection, and Repair.*

(1) Clean cushions with a damp cloth and dry. Inspect cushions for cracks both in cushion covering and in stiff backing. Replace as required.

(2) Inspect air spring (25) for cracks or hardness. Replace as required.

(3) Inspect shock absorber. Replace as required.

(4) Inspect all other parts for wear, cracks, or damage, replace as required.

*d. Assembly.* Assemble the seat assembly in reverse order of disassembly.

*e. Installation.* Refer to TM 5-3810-290-12 and install the seat assembly.



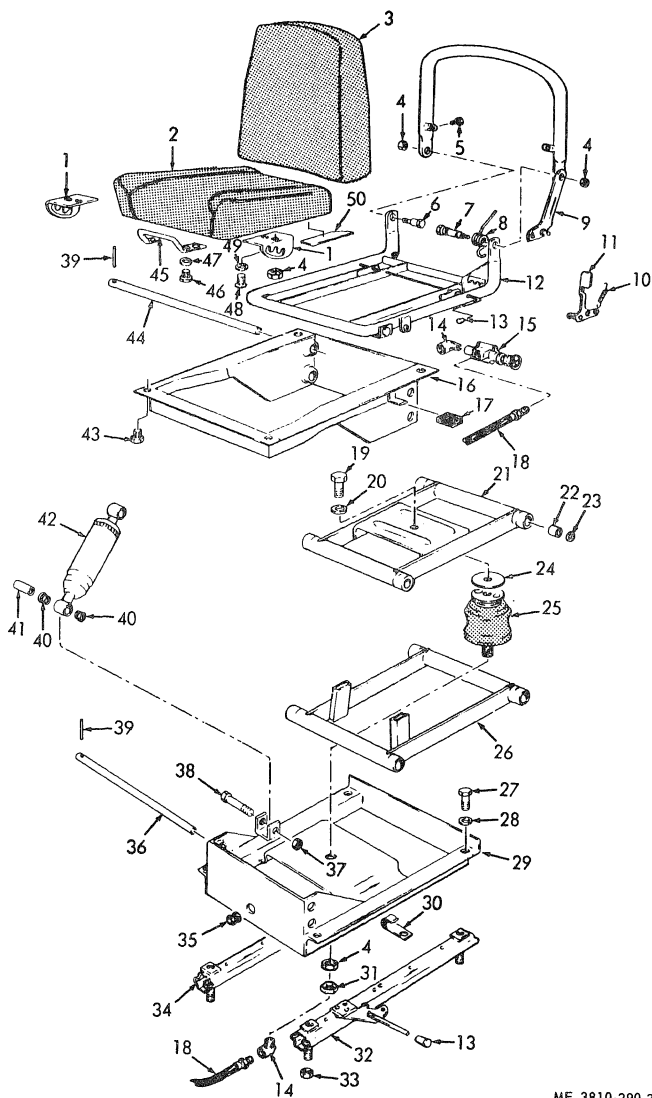


Figure 6-1. Seat assembly, exploded view.

KEY to figure 6-1.

1. Bracket, R.H.
2. Seat
3. Back cushion assembly
4. Nut (10)
5. Screw
6. Pivot pin, R.H.
7. Pivot pin, L.H.
8. Spring
9. Back frame assembly
10. Spring
11. Back control handle
12. Lower frame assembly
13. Handle tip (2)
14. Elbow (2)
15. Air valve assembly
16. Seat support assembly
17. Rubber bumper (2)
18. Hose assembly
19. Capscrew
20. Lockwasher
21. Upper arm assembly
22. Bushing (8)
23. Thrust washer (8)
24. Washer
25. Air spring
26. Lower arm assembly
27. Capscrew
28. Washer (8)
29. Lower frame assembly
30. Clip
31. Palnut
32. L.H. track assembly
33. Nut (4)
34. R.H. track assembly
35. Grommet
36. Front bearing shaft (2)
37. Nut (2)
38. Capscrew (2)
39. Roll pin (4)
40. Bushing (4)
41. Sleeve (2)
42. Shock absorber
43. Capscrew (4)
44. Rear bearing shaft (2)
45. Handle
46. Screw (8)
47. Lockwasher
48. Screw (4)
49. Lockwasher (4)
50. Wear plate

### 6-3. Cab Heater

*a. General.* The hot water cab heater is mounted on the bulkhead in the front of and to the left of the operator. A vertically-mounted, integral fan unit provides the air flow for heating and windshield defrosting. Two connections to the engine cooling system are required, with an adjustable thermostatic element controlling the water temperature. An instrument panel-mounted switch controls the operation of the heater fan.

*b. Removal.* Remove the cab heater (refer to TM 5-3810-290-12).

#### *c. Disassembly.*

(1) Remove the four screws (7, fig. 6-2) on the sides of the front panel (6) and drop the panel down.

(2) Slide core (4) from heater shell (1).

(3) Slide bottom plate (5) from heater shell.

(4) Remove nuts (2), lockwashers (3) and assembled motor (8) and fan (12).

(5) Further disassembly of motor and fan is not necessary unless replacement is required.

#### *d. Cleaning, Inspection and Repair.*

(1) Clean all parts of the heater assembly with a cloth moistened with an approved cleaning solvent. Dry thoroughly.

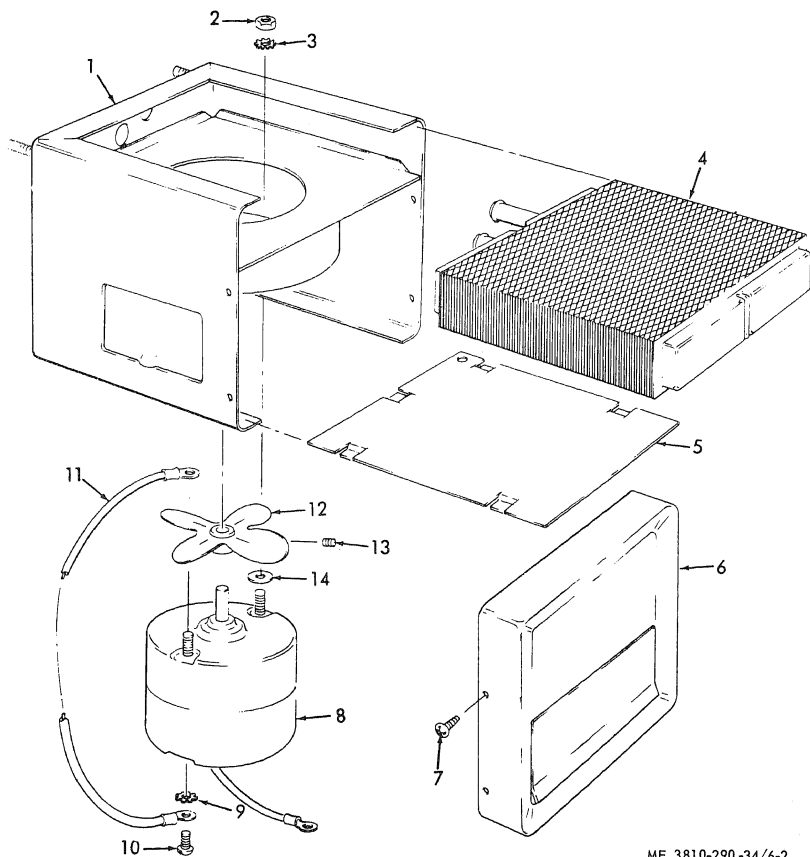
(2) Clean the heater core with compressed air.

(3) Inspect the motor assembly for worn bushings or excessive end play. Replace as required. Inspect the fan for cracked blades.

(4) Check the heater core by applying 10-12 pounds per square inch air pressure to the core while immersing in water. If core is defective, replace.

*e. Assembly.* Assemble the heater in the reverse order of disassembly.

*f. Installation.* Refer to TM 5-3810-290-12 and install the heater.



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1. Shell
2. Nut (2)
3. Lockwasher (2)
4. Core
5. Bottom plate
6. Cover
7. Screw (4)

8. Motor
9. Lockwasher
10. Screw
11. Lead
12. Fan
13. Setscrew
14. Flat washer

Figure 6-2. Cab heater assembly, exploded view.

#### 6-4. Panel Wiring

a. *General.* Replacement of electrical wiring is required when a defective condition has been noted. The following instructions for removal and installation will serve as a general outline for panel wiring.

##### b. *Removal.*

(1) Remove cab assembly (refer to TM 5-3810-290-12).

(2) Refer to wiring diagram in TM 5-3810-290-12.

(3) Remove rear instrument panel cover.

(4) Record wire numbers of leads connected to gage and disconnect the leads.

(5) Remove wire assemblies by recording wire numbers and their terminal points.

##### c. *Installation.*

(1) Install electrical wiring in reverse order of removal. Secure wire assemblies to chassis sufficiently to prevent chaffing of insulation from vibration.

(2) Refer to TM 5-3810-290-12 and install cab assembly.

#### 6-5. Cab and Cab Base

##### a. *Removal.*

(1) Remove the cab assembly (refer to TM 5-3810-290-12).

(2) Remove seat assembly (refer to TM 5-3810-290-12).

(3) Disconnect and remove panel mounted controls and instruments as necessary to remove instrument panels from cab base (20, fig. 6-3). Refer to TM 5-3810-290-12 for specific instructions on each control or instrument.

(4) Remove cab heater (refer to TM 5-3810-290-12).

(5) Remove spring (30), cotter pin (29), washer (28), and lever (27) from each side of cab base.

(6) Remove four drive screws (14) from each door assembly (26) and remove door assembly from cab base.

(6) Remove four drive screws (14) from each door assembly from cab base.

(7) Remove nine drive screws (25) and a ventilator frame (24) from each opening in cab base front.

(8) Remove the defroster nozzle (34) by

removing two screws (37), lockwashers (36), and nuts (35).

(9) Remove four capscrews (18), lockwashers (21), and nuts (22) that secure the cab base (23) to frame. Lift cab base from frame.

##### b. *Disassembly.*

(1) Remove dome light (refer to TM 5-3810-290-12).

(2) Remove windshield wiper motor (refer to TM 5-3810-290-12).

(3) Remove capscrews (1), nuts (5), lockwashers (4), plate (3), and lifting hook (2) from each side of cab (6).

(4) Remove two screws (13) and door handle from outside of door (16).

(t) Remove six screws (13) and lock assembly (14).

(6) Remove six flat head screws that secure door hinges to cab and remove door assembly (17).

(7) Remove two screws (12) and clips (11).

(8) Remove screws (7) and window frame (8). Remove glass panels (9) and lifts (10).

(9) Glass panels mounted in rubber retaining strips may be removed if required by the following procedure.

(a) Locate the butted ends of the rubber retaining strips and use an awl to pry out the end of the small insert strip from inside of molding.

(b) Pull insert strip by hand until its entire length is free from the molding.

(c) With the help of a second person to support glass on the inside, apply pressure on outside of glass until free from molding.

##### c. *Cleaning, Inspection and Repair.*

(1) Clean metal parts with a cloth dampened with cleaning solvent and dry thoroughly.

(2) Inspect metal parts for broken welds, cracks, dents, and worn or rusted spots. Repair broken welds, cracks, and dents where possible. Sand worn and rusted spots and repaint. Replace parts that are badly damaged.

(3) Inspect defroster hose (33) for cracked or frayed condition. Replace as required.

d. *Assembly.* Assemble the cab assembly in reverse order of disassembly.

e. *Installation.* Refer to TM 5-3810-290-12 and install the cab base and cab assembly.

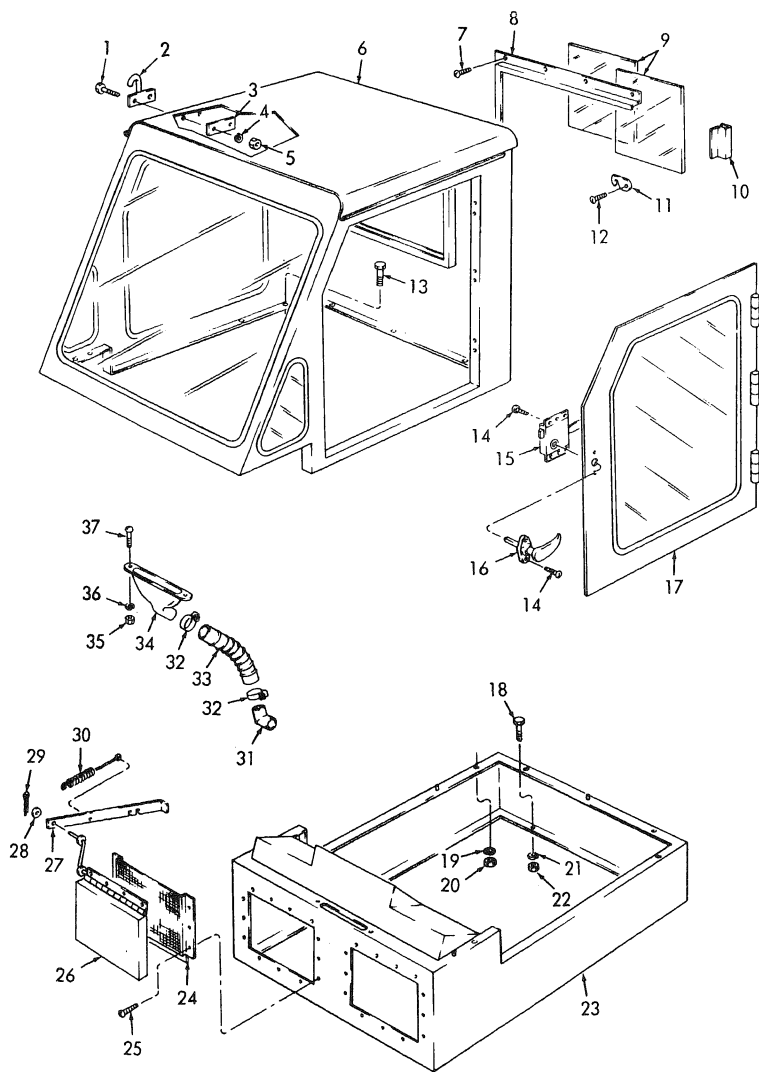


Figure 6-3. Cab and cab base, exploded view.

**KEY to figure 6-3.**

1. Capscrew
2. Hook
3. Plate
4. Lockwasher
5. Nut
6. Cab assembly
7. Screw
8. Frame
9. Glass (2)
10. Lift
11. Clip
12. Screw
13. Capscrew
14. Screw (8)
15. Lock assembly
16. Door handle
17. Door assembly
18. Capscrew
19. Lockwasher
20. Nut
21. Lockwasher
22. Nut
23. Cab base
24. Ventilator frame (2)
25. Screw
26. Door assembly (2)
27. Lever
28. Washer
29. Cotter pin
30. Spring
31. Elbow
32. Clamp (2)
33. Hose
34. Nozzle
35. Nut
36. Lockwasher
37. Screw

**6-6. Hood**

*a. Removal and Disassembly.* Refer to TM 5-3810-290-12 and remove and disassemble the hood.

*b. Repair.*

- (1) Replace a defective part.
- (2) Clean rusted areas, and repaint.
- (3) Replace webbing if excessively frayed or worn.

*c. Assembly and Installation.* Refer to TM 5-3810-290-12 and assemble and install the hood.

**6-7. Fuel Tanks***a. Removal.*

(1) Remove service air reservoirs (refer to TM 5-3810-290-12).

(2) Remove fuel tanks (refer to TM 5-3810-290-12).

*b. Disassembly.*

(1) Remove anti-squeak tape (8, fig. 6-4) from left side fuel tank (10).

(2) Remove cap (12), gasket (13), retaining chain (15), and fuel strainer (14) from left side fuel tank.

(3) Remove feed line tube (18) with plug (9), from left side fuel tank, and separate plug from tube.

(4) Remove screw (16), cover plate (19), and gasket (17) from left side fuel tank.

(5) Remove screw (16), sending unit (20), and gasket (17), from right side fuel tank.

(6) Remove feed line tube (18) from right side fuel tank.

(7) Remove cap (12), gasket (13), retaining chain (15), and fuel strainer (14) from right side fuel tank.

*c. Cleaning, Inspection, and Repair.*

(1) Refer to TB ORD 1031 (Purging and Cleaning Fuel Tanks) and clean the fuel tanks. Remove all sludge and deposits from tanks.

(2) Inspect filler cap, cap, gasket, strainer and fuel level sending unit for damage. Replace a defective part.

(3) Inspect the tank for cracks, holes, broken welds, and worn or rusted spots.

(a) Weld any broken welds, holes, or cracks in tank.

(b) Sand worn and rusted spots, and repaint.

*d. Assembly.* Assemble the fuel tanks in reverse order of disassembly.

*e. Installation.*

(1) Refer to TM 5-3810-290-12 and install the fuel tanks.

(2) Refer to TM 5-3810-290-12 and install the service air reservoirs.

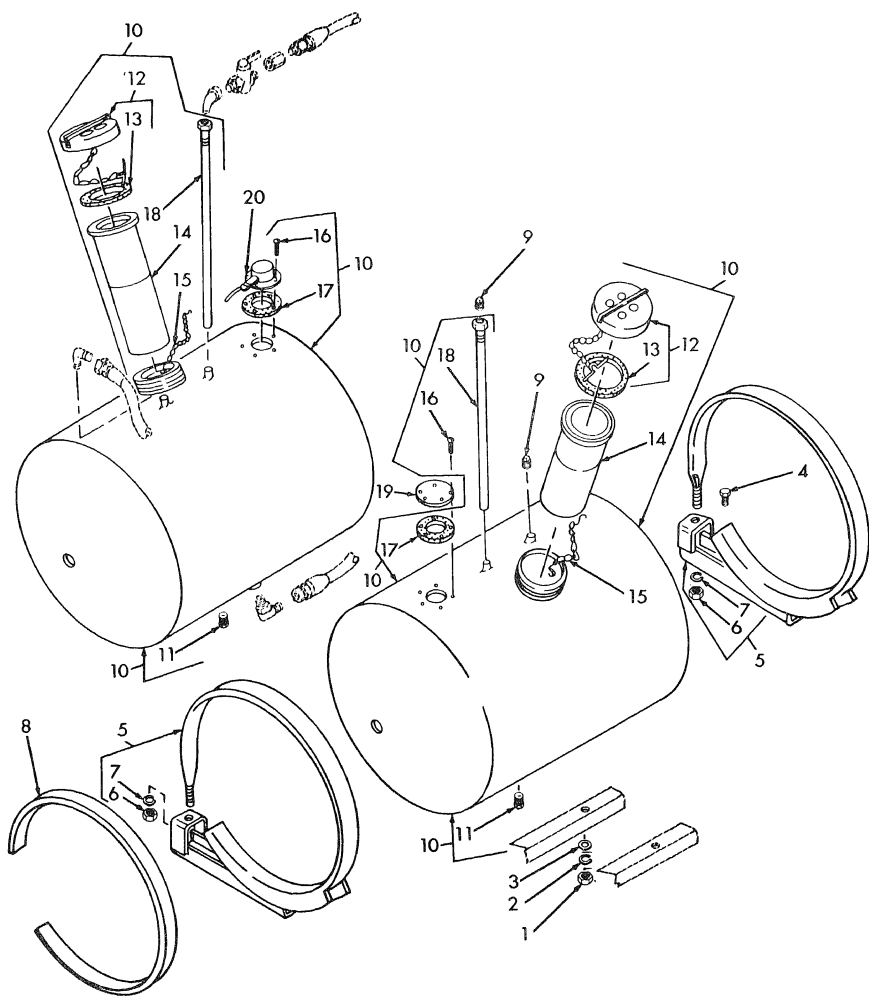


Figure 6-4. Fuel tanks, exploded view.

**KEY to figure 6-4.**

1. Nut (8)
2. Lockwasher (8)
3. Washer, flat (8)
4. Capscrew (8)
5. Bracket, mounting (4)
6. Nut (4)
7. Lockwasher (4)
8. Anti-squeak tape
9. Plug, pipe (2)
10. Fuel tank assembly (2)
11. Plug, drain (2)
12. Cap assembly (2)
13. Gasket (2)
14. Strainer (2)
15. Chain, retaining (2)
16. Screw (10)
17. Gasket (2)
18. Tube (2)
19. Plate, cover
20. Transmitter, liquid pressure (sending unit)

**6-8. Hydraulic Reservoir**

*a. Removal and Disassembly.* Refer to TM 5-3810-290-12 and remove and disassemble the hydraulic reservoir.

*b. Repair.*

(1) Replace defective parts.

(2) Weld any breaks or holes in cover or walls of reservoir.

*c. Assembly and Installation.* Refer to TM 5-3810-290-12 and assemble and install the hydraulic reservoir.

(1) Use new cover and level gage gaskets.

(2) Fill reservoir with clean hydraulic oil in accordance with lubrication order.

(3) Operate crane hydraulic system for a few minutes, and check reservoir and connections for leaks.

**6-9. Fenders**

*a. Left Front Fender.*

(1) Remove mirror assembly (refer to TM 5-3810-290-12).

(2) Remove light boxes (refer to TM 5-3810-290-12).

(3) Remove hydraulic reservoir (refer to TM 5-3810-290-12).

(4) Tag and disconnect hydraulic tubing that goes through fender.

(5) Remove nine carriage bolts (2, fig. 6-5), lockwashers (9), and nuts (10). Lift left front fender (3), from brackets.

(6) Release air pressure in air system and disconnect air line from service coupling mounted on bracket (18). Remove coupling from bracket.

(7) Remove two capscrews (16), lockwashers (20), and nuts (19), that secure brace (1), to

additional sets of hardware, two from right fender bracket and two from cab base.

(8) Remove four capscrews (12), lockwashers (13), and nuts (14), to remove brackets (17 and 18) from main frame.

*b. Right Front Fender.*

(1) Remove mirror assembly (refer to TM 5-3810-290-12).

(2) Remove light boxes (refer to TM 5-3810-290-12).

(3) Remove tool box (refer to TM 5-3810-290-12).

(4) Refer to *a* above and follow steps (5, 6, 7, and 8).

*c. Left Rear Fender.*

(1) Remove side panel (refer to TM 5-3810-290-12).

(2) Remove light boxes (refer to TM 5-3810-290-12).

(3) Remove hydraulic reservoir (refer to TM 5-3810-290-12).

(4) Remove nine carriage bolts (2, fig. 6-5), lockwashers (9), and nuts (10). Lift left rear fender (5) from brackets.

(5) Remove two capscrews (15), lockwashers (7), and nuts (6), that secure support (4) to bracket (11).

**NOTE**

If rear hood panel is still mounted on support (4, fig. 6-5), it will be necessary to block the support to prevent sagging and possible damage to exhaust pipes, etc.

(6) Remove four capscrews (12), lockwashers (13), and nuts (14), that attach brackets (8 and 11) to main frame.

*d. Right Rear Fender.*

(1) Remove side panel (refer to TM 5-3810-290-12).

(2) Remove battery box and slave receptacle (TM 5-3810-290-12).

(3) Refer to *c* above and follow steps (4), (5) and (6).

*e. Cleaning, Inspection, and Repair.*

(1) Clean all parts with cleaning solvent and dry thoroughly.

(2) Inspect all parts for cracks or broken welds. Weld cracks or broken welds where possible. Replace a badly damaged part.

(3) Remove any rust found and repaint.

*f. Installation.*

(1) Install fenders (a), (b), (c), and (d), in reverse order of removal.

(2) Refer to TM 5-3810-290-12 and install mirrors, light boxes, tool box, battery box, slave receptacle, and hydraulic reservoir.



(3) Connect hydraulic tubing that goes through left front fender.

KEY to figure 6-5.

1. Brace
2. Bolt
3. Fender
4. Support
5. Fender
6. Nut
7. Lockwasher
8. Bracket

9. Lockwasher
10. Nut
11. Bracket
12. Screw
13. Lockwasher
14. Nut
15. Screw
16. Screw
17. Bracket
18. Bracket
19. Nut
20. Lockwasher

ME 3810-290-34/6-5

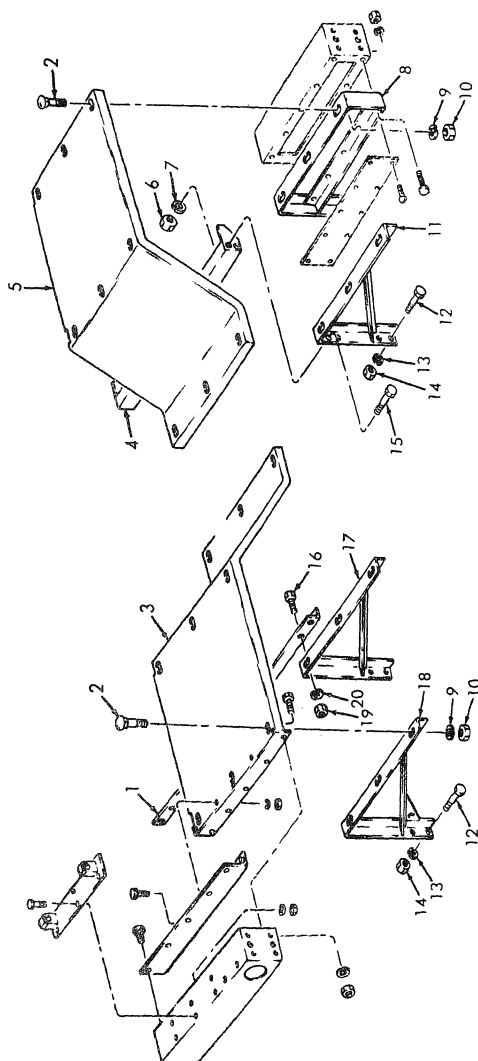


Figure 6-5. Fenders and brackets, exploded view.

## 6-10. Front and Rear Outriggers (Frames)

The front and rear outriggers (frames) are welded to the front and rear of the carrier frame. They support the outrigger arms. They are replaced only if they are extremely damaged.

### a. Removal.

(1) Remove outrigger arms (refer to TM 5-3810-290-12).

(2) Cut the weld which joins the front and rear outriggers to the carrier frame (fig. 2-4(1), (2), (3)), and remove outriggers.

b. Disassembly. Refer to figure 2-4 3 and disassemble rear outrigger.

### c. Repair.

(1) Straighten any bends in metal.

(2) Smooth out dents or rough areas.

(3) Weld any cracks or breaks in metal.

(4) Sand rusty areas and repaint.

d. Assembly. Reverse procedures in b above to assemble outriggers.

### e. Installation.

(1) Weld outriggers to front and rear frame of crane.

(2) Refer to TM 5-3810-290-12 and install outrigger arms.

## 6-11. Frame

a. General. The carrier frame is an open box type frame, composed of various types of structural steel welded together. There are two main members of the carrier frame; the main frame (1, fig. 2-4(1)), and the rear axle pivot frame (32). The repair of the frame is primarily limited to the rework of welds, filling cracks, and the replacement of various small brackets and braces that may require replacement. The location of a point of repair on the frame will dictate the need for component removal to provide access to accomplish the repair.

### NOTE

As the carrier frame members are of high strength steels, the following welding instructions must be followed in respect to each member to insure a proper weld.

### b. Main Frame Repair.

(1) The main frame is constructed of high strength steel, type T-1A. The following steps and conditions must be maintained when performing any welding operation on the main frame.

(2) Weld rods to be used are AWS (American Welders Society) number E12018 or equivalent coated electrode. Weld rods of 5/32, 3/16, 7/32 and 1/4 inch diameter are used on the main frame. The electrodes should be stored in an oven at 300 degrees Fahrenheit.

(3) Flame cut weld chamfers where required.

(4) Avoid excessive heat input while welding. Base metal, temperature normally 60° to 65° F. If moisture is present on metal, preheat to 100° F. to dry. An interpass temperature of 200° F. is desired, with 300° F. maximum. The maximum heat input during welding is 300° F.

### c. Pivot Frame Repair.

(1) The rear axle pivot frame is constructed of steel alloy Man-Ten and Ex-Ten 50.

(2) Weld rods to be used are AWSE7018 or equivalent for coated electrodes and AWSE70T2 or equivalent for MIG (Metal Inert Gas) wire. Electrodes of 5/32, 3/16, 7/32 and 1/4 inch diameter or MIG wire of 0.093 inch diameter are used on the pivot frame. The electrodes should be stored in an oven at 300 degrees Fahrenheit.

(3) Flame cut weld chamfers as required.

(4) A minimum base metal temperature of 35° F. is required before starting welding. Ambient temperature should be 40° to 45° F. or above during welding. Maximum heat input during welding is 500° F.

(5) If MIG process is used, the rate of flow of shielding medium should be 40 cubic feet per hour  $\pm$  40 percent depending on atmospheric conditions.

### d. Axle Housing Repair.

(1) The axle housing (both front and rear) are made of 1040 steel.

(2) Weld rods to be used are AWS E11018 or equivalent for coated electrodes and AWS E70T2 or equivalent for MIG wire. Electrodes of 5/32 and 3/16 inch diameter of MIT wire of 0.093 inch diameter are used on the pivot frame. The electrodes should be stored in an oven at 300° F.

(3) Flame cut weld chamfers as required.

(4) A minimum base metal temperature of 60° to 65° F. is required before starting welding. Maximum heat input during welding is 300° F. An interpass temperature of 200° F. is desired, with 300° F. maximum.

(5) If MIG process is used: CO<sup>2</sup> must be used for a shielding medium; and rate of flow of shielding medium of 40 cubic feet per hour  $\pm$  40 percent, depending on atmospheric conditions.

(6) After welding of axle housings, stress relief the housing as follows:

(a) Heat housing to 110° F. and hold the temperature 10 hours.

(b) Furnace cool to 700° F. to 800° F. and remove.

(c) Magnaflux or dye penetrant all welds after stress relieving.

## CHAPTER 7

MATERIAL USED IN CONJUNCTION WITH MAJOR ITEM

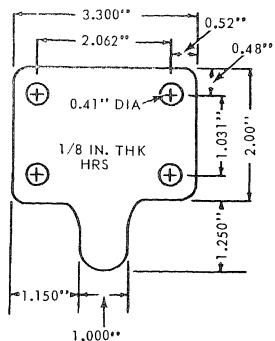
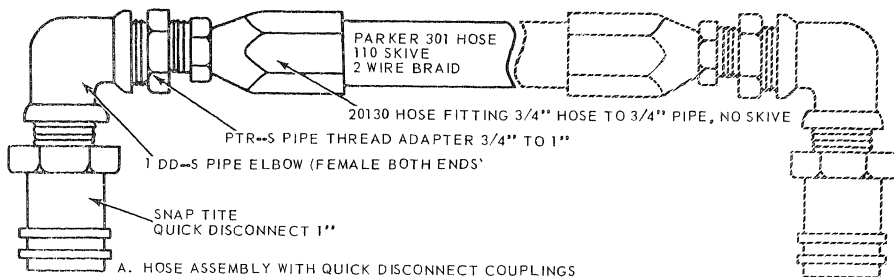
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**7.1 General**

This chapter covers the description, manufacture, installation, and operation of the hydraulic recovery kit supplied for use with the crane. The kit is used to recover cranes that have lost hydraulic power during craning operations. To successfully use the kit with the parts supplied, another model H446A Hanson crane must be available.

**7-2. Hydraulic Recovery Kit.**

a. *Description.* The recovery kit consists of 3, 18-foot hose assemblies with quick-disconnect couplings and fittings at each end (A, fig. 7-1), three metal port plates (B, C, and D, fig. 7-1). The plates supplied in the kit must be fabricated in accordance with the dimensions in figure 7-1.



PLATES:

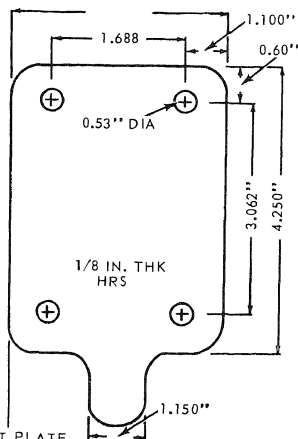
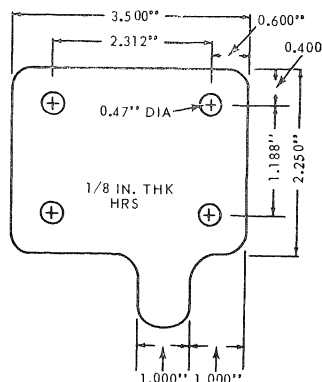


Figure 7-1. Hydraulic recovery kit.

### *b. Installation.*

(1) Aline the operational crane beside the non-operational crane and stop the engine.

(2) Disconnect the hydraulic pressure lines from the hydraulic pump of the non-operational crane (TM 5-3810-290-12).

(3) Position the fabricated blank port plates (B and C, fig. 7-1) over the ports of the pump and reconnect the pressure lines to the pump (with the port plates sandwiched between the pressure lines and the pump).

(4) Disconnect the coupling between test point "C" and the hydraulic filter of the non-operational crane. Refer to the Hydraulic system schematics diagram in TM 5-3810-290-12 for the location of test points.

(5) Position the fabricated blank port plate (D, fig. 7-1) at the disconnected coupling in (4), above, and reconnect the coupling (with the port plate sandwiched) between the parts of the coupling.

(6) Between the test points of the operational and non-operational cranes, connect the three hoses from "A" to "A", "B", to "B", and "C" to "C".

### *c. Operation.*

(1) Start the engine of the operational crane.

### CAUTION

**Do not start the engine of the non-operational crane with the blank port plates installed. To do so will destroy the hydraulic pump on the non-operational crane.**

(2) To operate a control of the seven-section valve on the non-operational crane, the operator of the operational crane must first position the clam bucket control in either the OPEN or CLOSED position.

(3) To operate a control of four-section valve on the non-operational crane, the operator of the operational crane must first position the boom control in the DOWN position (boom must be in full DOWN position and the control in the DOWN position to provide the required hydraulic restriction).

(4) Operate the hydraulic controls of the non-operational unit to attain a travel posture.

(5) Remove the hydraulic recovery kit.

(6) For towing instructions, if required, refer to TM 5-3810-290-12.



## APPENDIX A

## REFERENCES

**A-1. Fire Protection and Safety**

TB 5-4200-200-10

TB 5-4200-201-10

TB 385-101

Hand Portable Fire Extinguishers Approved for Army Users

Hand Portable Fire Extinguishers For Rail, Marine, Amphibious, and Off-road Equipment

Safe Use of Cranes, Crane Shovels, Dragline, and Similar Equipment Near Electric Power Lines.

**A-2. Lubrication**

C9100-IL

LO 5-3810-290-12

TB 703-1

TB 55-6650-300-15

Fuels, Lubricants, Oils, and Waxes

Crane, Wheel Mounted: 5 Ton, (Hanson Model H446A)

Specification List of Standard Liquid Fuels, Lubricants, Preservative- and Related Products Authorized for use by U.S. Army Spectrometric Oil Analysis.

**A-3. Painting**

AR 740-1

AR 746-5

TB 740-931

TM 9-213

Color, Marking, and Preparation of Equipment for Shipment

Color and Marking of Army Materiel.

Color and Marking of Military Vehicles, Construction Equipment, and Material Handling Equipment

Painting Instructions for Field Use

**A-4. Cleaning**

C6800-IL

SB 725-7930-1

TB SIG-327

Chemical and Chemical Products.

Hand and Salt-Water Cleaning Compound

Substitutes for Carbon-Tetrachloride

**A-5. Maintenance**

FM 29-2

SB 700-50

TB ORD-1031

TB 750-651

TM 9-6140-200-20

TM 9-6140-200-15

TM 38-750

TM 5-3810-290-12

TM 5-3810-290-20P

TM 5-3810-290-34P

Organizational Maintenance Management

Expendable Limits (up to \$25).

Purging and Cleaning Fuel Tanks

Use of Anti-Freeze Solutions and Cleaning Compounds in Engine Cooling Systems

Organizational Care, Maintenance, and Repair of Pneumatic Tires and Inner Tubes

Lead-Acid Type Batteries

The Army Maintenance Management System

Operator and Organizational Maintenance Manual; Crane; Wheel Mounted; 5 Ton, (Hanson Machinery Co., Model H446A)

Organizational Maintenance Repair Parts and Special Tools Lists: Crane, Wheel Mounted; 5 Ton; (Hanson Model H446A).

Direct Support and General Support Repair Parts and Special Tools Lists (Including Depot Maintenance Repair Parts and Special Tools Lists) Crane, Wheel Mounted; 5 Ton; (Hanson Model H446A)

**A-6. Shipment and Storage**

SB 38-100

TM 38-230-1

TM 740-90-1

Army Preservation, Packing, and Marking Materials, Supplies, and Equipment

Preservation and Packing of Military Equipment

Administrative Storage of Equipment

**A-7. Demolition**

TM 750-244-3

Destruction of Materiel to Prevent Enemy Use



**A-8. Operation**  
**TM 5-331B**

**Lifting, Loading, and Handling Equipment.**

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By Order of the Secretary of the Army:

CREIGHTON W. ABRAMS  
*General, United States Army*  
*Chief of Staff*

Official:

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